APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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APPLIED MECHANICS REVIEWS

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WATER WAVES

J. D. PIERSON

NAVAL ARCHITECT, THE MARTIN COMPANY, BALTIMORE 3, MARYLAND

INTRODUCTION

The appearance of the water when disturbed by waves has fascinated both casual and scientific observers for a long time. Recent articles and books such as Bascom (1) and Carson (2) summarize the physical characteristics of waves in a popular manner. The regular patterns from local disturbances in otherwise calm water, the everchanging aspects of wind-driven waves, and the tremendous power evident in storms have challenged the analytical talents of many of these observers. Over the years the literature has grown to such an extent that it is fortunate that several excellent recent works are available to serve as a collection, correlation, and unified presentation of past efforts of investigators. Wehausen (3) has recently completed a thorough presentation of the analytical forms of waves. Stoker (4) combines the mathematical theory with physical interpretation to a wide range of water-wave phenomena. Lighthill (5) covers the special field of river waves from the analytical viewpoint. The practical effects of water waves in ship design have been summarized by Saunders (6) and Johnson (7). Characteristics of actual ocean waves and the basis for forecasting are given by Sverdrup (8), Bigelow (9) and Bracelin (10). Recent developments in the statistical evaluation of water waves and the needs for future research in connection with long-range ship design development programs are given by Pierson (11).

Since there are already in existence ample reviews of the early literature on water waves, no attempt will be made in this review to provide an extensive bibliography—even though many of the original reports may be quite applicable today. Rather it is intended that some indication be given of the current activity and persons engaged in various aspects of water waves. The review is further limited to those water-wave phenomena in which gravity plays a major role. For convenience, a division into three categories will be used: (a) waves generated by a discrete disturbance, (b) oscillatory waves, and (c) wind-generated waves.

WAVES GENERATED BY DISCRETE DISTURBANCES

Many waves can be traced to a well-defined origin such as an explosion or boundary upheaval, motion of a pressure source through or over the water, flow over an obstacle or the addition of large quantities of additional water to a bounded system. Such waves are usually regular in form both in appearance and repeatability. They have the characteristics of various types of analytical forms of water-wave theories, partly from the "simplicity" of the problems and partly because the physical evidence may be directly correlated with the analytical forms.

The plop of a pebble in a still pool produces a fascinating set of waves familiar to everyone. On a larger scale this becomes the devastating local waves of a major underwater explosion. The prediction of wave form and height for large underwater explosions has been the subject of recent study with the advent of nuclear explosions. The effect of the explosion may be represented by a sudden change in height of the water surface which is released at time zero. The form of waves produced in the two-dimensional problem check fairly well with experimental results, Prins (12). Kranzer (13) considers also the problem where the explosion is represented by a localized pressure, suddenly applied. The agreement with experiment in both two- and three-dimensional problems is good. The explosion can be represented by impulses in pressure or initial wave of equal energy, but exact matching will require further work in assigning the portion of the total explosive energy which is transferred to the formation of waves.

In the formation of tsunamis there is a massive shift of boundary over a large area. Although the motion may not be very great, the area and total energy involved may be phenomenally large compared to artificial disturbances such as man-made explosions (at least up to the present). The result in deep water is a very long wave of low amplitude which may not even be noticed by ships at sea. However, the piling of this energy upon obstacles, such as the shoreline, greatly increases the height of the waves to cause severe damage on anything in its way, Bernstein (14) and Roberts (15).

Seismographs will give ample evidence of earth tremors which might be possible sources of tsunamis, Gutenberg (16), but not many of these tremors generate waves of dangerous magnitude. The deep water wave formed has a low amplitude but very great length (high speed and long period). Thus the forecasting of probable areas of dangerous waves following an earthquake or similar disturbance at sea is difficult (because of the small wave height) and must be done with reasonable speed (because of the rapid advance of the waves). A network of stations has been put in service in the Pacific which is designed to detect the passage of such long period waves. Interpretation of the amplitude, time delay from suspected origin and period provide a basis of warning to potential danger areas, Van Dorn (17).

Waves somewhat like the tsunami of the ocean are sometimes generated on a smaller scale by the passage of relatively sudden pressure changes associated with severe storm conditions. The Great Lakes regions and North Sea areas have

experienced this type of wave to a serious extent. Also, the excessive tide rise within tropical storms is associated with this type of disturbance. Wiegel (18) provides a recent analysis of the form and magnitude of such waves generated by a moving low-pressure area.

Flow conditions in rivers and channels involve special wave problems due to the restrictions to the motion and the increased effect of damping due to boundary friction. Lighthill (5) provides a recent summary emphasizing the energy relationships in the significant properties and methods of analysis for tidal bores, roll waves, standing waves, flood waves and similar phenomena. Stoker (4) shows the feasibility of using the basic hydrodynamic equations for flood stage determinations and similar river wave problems. This is made possible through the effective programming of the inputs and boundary conditions for specific problems on large-scale automatic computational devices so that the exact equations may be solved by a step-by-step process.

Waves accompanying the motion of a ship through the water are typical of a different type of discrete disturbance. Here the moving body continually supplies energy to the wave motion which spreads out from the ship and gradually dissipates at a great distance. Saunders (6) gives a recent summary of this type wave, covering the mechanism of the wave formation, special effects of restricted water and the corollary effect of wave making on the resistance of the ship. Recent work by Pond (19) extends the work on analytical representations of ship forms to determining moments and pressure waves accompanying a submerged body. Borden (20) determines the potential function for hydrofoil-type vessels in shallow water which are related to the surface waves and subsurface pressure waves. De Prima (21) and Hunziker (22) examine the free surface wave form caused by a moving submerged object. The application of automatic computational machines to the ship wave problem by Di Donato (23) and Hershey (24) is indicative of the progress that may be made, with restrictions of manual calculations practically removed.

OSCILLATORY WAVES

Many of the simple wave forms can be reflected from a beach or other barrier to present a pattern of oscillatory waves. However, the special class intended here is composed of those generated where the water is basically enclosed and is excited by an adjoining disturbance. The key to the formation of such waves is that the disturbance possess some energy in the frequency bands near the natural frequencies of the enclosed body of water. Familiar examples occur in the hand-carried water pail or the dining car coffee cup.

The possibility of such oscillations in bays, lakes and harbors depends upon size, shape and depth of water. A study of particular types has been made by Carr (25) and McNown (26) from both the analytical and experimental model approaches. The determination of the natural frequencies for more complicated forms of harbors or lakes can be made by the method of finite differences, Stoker (4).

An area of widely different application of the same principles may be noted in the sloshing of liquids in containers. High interest in the effect of liquid propellants in missile dynamics has led to considerable study of the motions, Eulitz (27), and methods of damping of fluids with free surface in conditions of forced oscillation, Eulitz (28) and Miles (29).

WIND GENERATED WAVES

It is obvious to the most casual observer that wind blowing across a water surface causes waves. These waves are small at first and increase with size as the wind persists and as the observer moves downwind. If the wind dies down, the smaller ripples quickly vanish, but the longer waves persist for some time. A more exact description of sea surface wind waves and the actual mechanisms by which the energy is transferred from the wind to the water are far more complex than such casual viewing might suggest.

Boundary-layer conditions in the shear flow of the air across the water and air pressure fields induced over the wave contours can both provide generating forces for waves. Ursell (30) presents a fairly complete survey of the theories of wind-wave generation. Recent contributions to the field have been made by Phillips (31), Burling (32), and Friedman (33). Many sizes and proportions of waves exist simultaneously in the wind-driven sea. With each varying gust of air exciting new waves and adding to existing ones, there is little possibility of forming orderly progressions of uniform waves. A precise description cannot be given in terms of specific wave heights or periods because of the ever-changing pattern. Instead, the sea is described by the relative energy level as a function of the period of the waves.

Analytical models to represent such a sea surface in a statistical manner have been developed by Longuet-Higgins (34), Neumann (35), Pierson (36, 37), St. Dennis (38), and Darbyshire (39). These all recognize the existence of a spectrum of waves in a real wind-generated sea, and they differ mainly in the manner of distributing and summing-up the components of the total spectrum. Actual wave records at sea have been difficult to obtain and require lengthy analysis, but enough data have been obtained from direct measurements to basically confirm the analytic representations, Neumann (40), Pierson (41) and Kinsman (42).

Current efforts are being directed toward refinements in these descriptions of wind waves. Measurements of actual sea surface by sterophotogrammetric methods, Marks (43), analysis of sun glitter and other visual clues, Cox (44), have provided data for defining the directional distribution of the wave energy spectrum, Munk (45) and Pierson (46). Direct superposition of component waves in the random sea analytical models leads to excessive heights, since no allowance is made for the limitations of breakers. Recent results of work by Pierson (47), Milne-Thompson (48) and Tick (49) on nonlinear theory show significant limitations to the simple spectrum. Methods of forecasting particularly slanted toward the highest waves existing in given conditions have been examined by Chappalear (50), Walden (51), and Bretschneider (52) with considerable success in correlation with actual occurrences. In general, the current state of analysis of the wind-generated waves has fostered such progress in the art of forecasting the sea conditions that real aid is possible to marine navigation in planning best routes for shipping, James (53).

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Physics, General

Book—1. Key, E. G., Elementary engineering mechanics, New York, John Wiley & Sons, Inc., 1960, xvi + 457 pp. $5.50.

This book is produced for the technical programs in America in which no calculus is used. A service is hereby rendered for indicating the sharp distinction between a technical training and an engineering education. If engineering courses in statics and dynamics are to be distinguished from those in the technical institutes, then the vigorous and generous use of calculus and differential equations are long overdue.

Author provides the text in the customary two parts, namely, statics in Part I and dynamics in Part II. Part I deals with the usual topics at this textbook level, such as general concepts, simple force systems, nonconcurrent forces in a plane, couples and centers of gravity, friction, noncoplanar forces and a discussion on trusses. The short discussion on friction is good. Sketches are clear and revealing.

In Part II motion is discussed under rectilinear, angular, simple harmonic, and forces producing motion. The book closes with a chapter on work and energy; and momentum and power.

When the author does not use the calculus, other attacks are needed to handle simple harmonic motion and moments of inertia.

There are many examples and well-worded problems with answers to odd-numbered questions. The appendix contains a table of mass moments of inertia for simple shapes and a brief table of natural trigonometric functions. H. Majors, Jr., USA

Book—2. Higdon, A., Ohlsen, E. H., and Stiles, W. B., Mechanics of materials, New York, John Wiley & Sons, Inc., 1960, xiv + 502 pp. $7.75.

Book is one of a great number of similar tests, intended for undergraduate work. Elementary strength of materials (first course level) is presented without any noticeable novelties. Problems (768), to more than half of which answers are given, largely tend to hide the theoretical presentation. Reviewer feels that recent comments on similar texts in mechanics [AMR **12**(1959), Revs. 1688, 4838] apply also to this book. J. Hult, Sweden

Book—3. Machinery Handbook. Vol. 1, no. 3, Engineering measurements [Mechanik poradnik techniczny, Tom 1, Czecz 3], Warszawa, Panstwowe Wydawnictwo Techniczne, 1960, xvi + 1124 pp. zl 103.

The book is concerned with a comprehensive treatment of techniques, theories and underlying philosophy of engineering measurements. It pertains to measurements of time, length, areas, surfaces, volumes, linear and angular velocities, accelerations, frequencies, mass, density, forces, moments, stresses, strains, hardness, pressure, vacuum, surface tension, viscosity, flow, acoustic properties, sonic, ultrasonic phenomena, temperature, colorimetric phenomena, heat transfer, humidity, combustion, pH, optical and photo phenomena, color, electromagnetic and nuclear quantities.

Statistical theory of errors and international physical and engineering measuring systems have been discussed on the background of an extensive bibliography composed of Polish, Russian, German, French and English references. Very handy and useful text.

M. G. Bekker, USA

Book—4. Crandall, S. H., and Dahl, N. C., edited by, An introduction to the mechanics of solids, New York, McGraw-Hill Book Co., Inc., 1959, ix + 444 pp. $8.50.

This book, written by members of the Mechanical Engineering Department of Massachusetts Institute of Technology, introduces the mechanics of rigid and deformable bodies in static equilibrium to the undergraduate. The analysis of systems considered is based on (a) a study of forces and moments for equilibrum; (b) a study of deformation and conditions of geometric fit; (c) the application of force deformation relationships. In general, the satisfying of the above steps will lead to the required solution but in some cases the complexity of the physical situation and the difficulty of defining a sufficiently accurate and simple enough model will defeat analysis.

The scope of the book can be gaged from the chapter titles and remarks below. (1) "Fundamental principles of mechanics" introduces the force and moment balances required for static equilibrium and the methods of setting up the necessary equations. (2) "Introduction to mechanics of deformable bodies" goes on to bring into the analysis elastic deformation and force relations. (3) "Forces and moments transmitted by slender members" shows how to determine shear force and bending moment distributions in beam-type members under various loading systems. (4) "Stress and strain" develops equations for stresses or strains in a plane section to the components in arbitrary directions and introduces the concept of principal planes of stress and strain. (5) "Stress-strain-temperature relations" discusses stress-strain curves, elastic and plastic deformation, types of failure and temperature effects for engineering materials. Poisson's ratio, Hooke's law and associated phenomena are covered. Chapter titles (6) "Torsion", (7) "Stress and deformation in pure bending," and (8) "Deflections due to bending" are self-explanatory. The last chapter, "Stability of equilibrium: buckling," gives a brief survey of how to find the danger of instability-type failures.

The book is well written and most of the discussion is lucid, although reviewer believes that elaboration of some points would be essential for a full understanding. The discussion on the use of Mohr's circle representation for stress and strain and that on the two different criteria (Mises and maximum shear stress or Tresca) for relating yield in a general state of stress to that for the simple tensile test are particularly comprehensive and clear. Limit analysis is shown for torsion and bending and the formation of plastic hinges in beams and struts and their effects clearly demonstrated. The text is well illustrated by worked examples and figures, and formulas are clearly numbered.

Each chapter is followed by a number of relevant problems worded in an interesting way, with answers to many of them at the back of the book. There are two points of criticism reviewer has to make. In many of the problems the information is incomplete or ambiguous and the student has to pick values of constants from ranges quoted in the text appropriate to those used in the answer solution. Answers are not given for all the problems and reviewer has noted some as incorrect. The meanings of the symbols used are explained in the text, but the lack of a consolidated table of notation reviewer considers a mistake. The book ends with a fairly comprehensive index.

This book might well form the basis of an introductory course but as the text has been kept simple it would require supplementing by the more usual books on the subject. It is printed in the usual delightfully clear manner on good paper one has come to associate with books from McGraw Hill but for the ground covered reviewer believes price to be high.

A. F. W. Langford, Australia

Book—5. Shames, I. H., Engineering mechanics, Vols. 1 and 2: Statics and Dynamics (combined volumes 1 and 2), Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1960, xiv + 656 pp. $9.75.

See AMR **13**(1960), Revs. 6166 and 6167.

Analytical Methods in Applied Mechanics

(See also Revs. 4, 20, 38, 45, 49, 53, 54, 55, 57, 66, 71, 72, 79, 88, 121, 129, 133, 134, 195, 196, 208, 260, 261, 273, 300, 304, 321, 322, 354, 357, 419, 428, 535)

Book—6. Pipes, L. A., Applied mathematics for engineers and physicists, 2nd ed., New York, McGraw-Hill Book Co., Inc., 1958, ix + 723 pp. $9.50.

The new (second) edition of this book has been considerably strengthened by the addition of new material. The volume will have a wide appeal to people in the fields of engineering, applied mechanics, applied mathematics and physics, up through the Masters level.

The text covers a very large variety of material in advanced calculus, ordinary and partial differential equations, Fourier analysis and transform theory, complex variable theory and the Laplace transform, nonlinear differential equations, calculus of variations, matrix analysis, vibration theory and vector and tensor analysis. The material is presented in twenty-two chapters, and references and problems are given at the end of each chapter.

As is almost inevitable when such a large variety of topics is considered, some of the material is treated rather briefly. However, in most cases, author has done an excellent job in presenting clear and lucid explanations within the confines of his space limitations. Particular emphasis is given to physical applications of the mathematical theory with special sections on the vibrations of discrete and continuous elastic systems, oscillation of linear lumped electrical circuits and the analysis of nonlinear oscillatory systems. The text covers many of the situations and techniques that the practicing engineer and applied physicist will encounter in their work.

Reviewer is favorably impressed with the fact that the author generally indicates situations in which advanced techniques apply and for which further study beyond the scope of the text is required. A danger inherent in all books of this type is that the student may tend to look upon it as the last work on the subject, unless the need for further study is pointed out to him.

The chapter on linear algebraic equations, determinants and matrices is particularly complete and good. Also worthy of special mention is an introduction to the analysis of nonlinear oscillatory systems. Reviewer would appreciate more emphasis on the role of contour integration in the inversion of Laplace trans-

forms. Some of this material is presented in the chapters on complex variables and the Laplace transform.

Reviewer is favorably impressed with this volume and feels that it should prove useful for engineers and physicists. It is also quite suitable for use as a text in a graduate study course in advanced mathematics. Reviewer feels that it is certainly one of the better books of this type. M. L. Baron, USA

Book—7. Kamke, E., Differential equations; Methods for solution and solutions, Vol. 1: Ordinary differential equations, 6th ed.; Vol. 2: First-order partial differential equations for required functions, 4th ed. (Differentialgleichungen Lösungsmethoden und Lösungen, Vol. 1: Gewöhnliche Differentialgleichungen; Vol. 2: Partielle Differentialgleichungen erster Ordnung für eine gesuchte Funktion), Leipzig, Akademische Verlagsgesellschaft, 1959, xxvi + 666 pp., DM 36.80; xv + 243 pp., DM 16.

First edition of these books was printed at the end of the first world war. Since then Vol. 1 has come out in five new editions, which should indicate that the book has been appreciated.

Few changes have taken place in the first two sections of Vol. 1, containing A, general procedures for solving ordinary differential equations (p. 1–181) and B, theory and solution of boundary and eigenvalue problems (p. 182–288). In a third section, C, a number of new differential equations have been added, and we find now the solution of about 1600 differential equations, systematically ordered (p. 289–660).

The first section of Vol. 2, treats general procedures for solving partial differential equations of first order for required functions (p. 1–135). Next we find the solution of a great number of special equations (p. 136–240). Few changes have been made over previous editions. S. E. Kindem, Norway

Book—8. Franklin, P., Differential equations for engineers, New York, Dover Publications, Inc.,1960, vii + 299 pp. $1.65. (Paperbound)

This Dover edition is an unabridged and unaltered republication of the first edition of the work first published under the title "Differential equations for electrical engineers" in 1933. Ed.

Book—9. Greenhill, A. G., The applications of elliptic functions, New York, Dover Publications, Inc. 1959, xi + 357 pp. $1.75. (Paperbound)

This new Dover edition is an unabridged, unaltered republication of the work first published in 1892. Ed.

10. Lillo, J. C., A note on the continuity of characteristic exponents, *Proc. Nat. Acad. Sci.* **46,** 2, 247–250, Feb. 1960.

Author considers the system:

$$\dot{x} = A(t)x \qquad [1]$$

where $A(t)$ is a matrix, $\|A(t)\|$ its norm, and $\|A\| = \underset{t \in R}{l.u.b.} \|A(t)\|$. R is the real axis or the positive real axis. He defines the number

$$\lambda(A) = \overline{\lim_{t \to \infty}} \left[\underset{\varphi(t), t_0 \in R}{l.u.b.} \{ \ln (\| \varphi(t_0 + t) \| / \| \varphi(t_0) \|) / t \} \right].$$

major characteristic exponent. Here the *l.u.b.* is over all nontrivial solution of [1]. Author proves that $\lambda(A)$ is an upper semicontinuous function of $\|A\|$. The theorem is applied to some problems in theory of perturbations. D. Graffi, Italy

11. Popov, A. A., Orthogonal polynomials with arbitrary exponents (in Russian), *Inzbener. Sbornik, Akad. Nauk SSSR* **26,** 280–284, 1958.

Let a, b, c, ... be real numbers such that none is $-1/2$ or -1 and such that the sum of any two is not -1. Via a variational (least-squares) approach, author orthogonalizes the sequence of powers x^a, x^b, x^c, ... on an interval $[0, l]$.

B. R. Gelbaum, USA

12. Shapiro, H. S., and Silverman, R. A., Alias-free sampling of random noise, *J. Soc. Indust. Appl. Math.* **8,** 2, 225–248, June 1960.

Although primarily intended for mathematicians, this paper is of interest to anyone having to deal with the measurement of stationary random processes in the physical sciences (e.g. acoustics, turbulence, gust analysis, wave height analysis, etc.). Whenever a continuous record is sampled at discrete times to obtain data from which an energy spectrum (or autocorrelation function) is to be computed, the problem arises of the appearance of spectral components caused by the sampling, and not present in the original record; this is called aliasing. The authors examine this problem analytically, discussing uniformly spaced samples and two kinds of randomly determined sampling intervals. After defining aliasing, and developing techniques for determining if a given sampling method is alias-free (applying these to several cases), they obtain a sufficient condition under which a particular class of methods is alias-free, and display several alias-free members of this class. In addition to examining the problem with some generality, reviewer believes that the alias-free methods presented should be useful in practice. The authors do not discuss the related problem of finite samples taken from an infinite record [see Tukey, J. W., *Bell Systems Tech. J.* **37,** pp. 155–282, 485–569, 1958 in this connection and for general background].

J. L. Lumley, USA

Book—13. Hohn, F. E., Applied Boolean algebra—an elementary introduction, New York, Macmillan Co., 1960, xx + 139 pp. $2.50. (Papberbound)

This little book affords an introduction to the subject for both engineers and mathematicians; hence a minimum of engineering and mathematical background is assumed. Boolean algebra is presented in the introduction by giving postulates and basic laws. Then, in three chapters, its relations to relay circuitry, propositional logic, and set theory are described. In the final chapters applications to the minimization problem for switching circuits is briefly treated. The presentation is clear.

Simple network problems are used to illustrate all main points and serve to make abstract ideas intuitively grasped.

Reviewer believes this book will well serve its purpose as an introduction for engineers and mathematicians and also that the book is worth reading by many computer programmers and system analysts. B. Langefors, Sweden

Computing Methods and Computers

(See also Revs. 13, 52, 130, 509, 524, 556)

14. Juncosa, M. L., and Mullikin, T. W., On the increase of convergence rates of relaxation procedures for elliptic partial difference equations, *J. Assn. Comput. Machy.* **7,** 1, 29–36, Jan. 1960.

Authors believe that a more satisfactory rate of convergence will result for points near the edge of a region if the unknown values there are removed by a Gaussian elimination. The rate of convergence for such points is sometimes slow because of the change in grid spacing that occurs near an irregular boundary.

N. C. Costakos, USA

15. Glenisson, Y., and Derwidue, L., A new method for the calculation of zeros of polynominals (in French), *Acad. Roy. Belgique, Bull. Cl. Sci.* (5) **45,** 3, 197–204, 1959.

The roots of an nth-degree polynominal are determined by means of an $n-1$-degree polynomial using the Lagrange interpolation polynominal. The method is suitable for calculation with desk calculators and will be illustrated by a numerical example in a later note. N. C. Costakos, USA

Book—16. Williams, S. B., Digital computing systems, New York, McGraw-Hill Book Company, Inc. 1959, x + 229 pp. $7.75.

The purpose of this book is to describe the structure of the modern electronic computing systems in a manner understandable to those who are familiar with electrical circuits and apparatus but who have little or no knowledge of mathematics.

Ed.

17. Pawlak, Z., Organization of the address-free digital computer for calculating simple arithmetical expressions, *Bull. Acad. Polonaise Sci. (IV)* **8,** 4, 193–195, 1960.

18. Pawlak, Z., The organization of a digital computer based on the "–2" system, *Bull. Acad. Polonaise Sci. (IV)* **8,** 5, 253–258, 1960.

19. Douglas, J., Jr., An unusual stability criterion for a difference analogue of the heat equation, *J. Math. Phys.* **38,** 2, 150–152, July 1959.

In the numerical solution of the heat equation by a difference equation, it is frequently necessary to impose a restriction between the time increment k and the space increment b of the form $0 < \rho \leq c < \infty$, where $\rho = kb^{-2}$. Author states that in attempting to develop a high-order correct difference analog of heat equation in two variables, difference equations were developed for which it is necessary that $0 < c \leq \rho < \infty$ for stability and convergence. Such a requirement had not been obtained previously.

However, reviewer notes that because of an error the difference equation obtained (author's Eq. [2.7]) is not high-order correct. Error occurs in author's Eq. [2.2] for the nine-point difference operator; this equation should be $Mu = 6b^2[\nabla^2 u + \frac{b^2}{12}\nabla^4 u + O(b^4)]$ where M is the difference operator

$$Mw_{ij} = 4(w_{i+1,j} + w_{i-1,j} + w_{i,j+1} + w_{i,j-1}) + w_{i+1,j+1} + w_{i-1,j+1} + w_{i-1,j-1} + w_{i+1,j-1} - 20\, w_{i,j}$$

$w_{ij} = w(ih,\ jk)$

and ∇^2 is the Laplace operator.

In a private communication to reviewer, author pointed out that in a somewhat artificial sense his Eq. [2.7] can still be studied, since it is a convergent analog of the differential equation $\frac{\partial u}{\partial t} = \frac{1}{2}\nabla^2 u$, but it is not high-order correct. The local truncation error is $O(b^2 + k + b^4k^{-1})$ and if $\rho \geq \frac{5}{4}$ so is the global error. Thus, although of no interest for numerical solutions, the unusual stability criterion mentioned does apply.

H. G. Landau, USA

20. Chaudhuri, A. K., Solution of boundary value problems using electronic differential analyzer, *J. Sci. Engng. Res., India* **3,** 2, 393–408, July 1959.

Analogies

(See also Revs. 281, 288, 303, 532)

21. Monastyrshin, G. I., Mathematical simulation of dry friction, *Automation and Remote Control* **19,** 12, 1063–1076, June 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 12, 1091–1106, Dec. 1958 by Instrument Society of America, Pittsburgh 22, Pa.)

Paper is an English translation of a Russian paper read at the seminar on the theory of automatic control at the Institute of Automation and Remote Control of the USSR, Academy of Sciences.

One of the fields where d c analog computation has been applied very successfully is in the design of modern automatic control systems where it often becomes necessary to simulate nonlinear process due to dry friction. The paper deals with three cases: when starting friction is equal to kinetic friction, when it exceeds the latter and when it depends on the duration of the contact at rest. Differential equations for sliding bodies with dry friction under conditions stated above have been derived and detailed circuits for simulating on a particular computer are described. The results are represented by oscillograms, and circuits thus tried are used as part of other circuits for simulating more complex processes, such as the small oscillations of a gimbal gyroscope axis. High frequency differentiating amplifiers have been used for simulation of sliding with dry friction involving equations with higher order derivatives.

All the references in the paper are Russian publications and the computer discussed is also of Russian origin. Familiarity with these, though not necessary, will make it more easy to follow the paper. In Eq. [3] the left-hand-side term should read $m\ddot{x}$ and the symbol n in one of the right-hand-side term stands for coefficient of restitution and not for coefficient of inertia.

B. M. Belgaumkar, India

22. Vines, R. G., The damping of water waves by surface films, *Austral. J. Phys.* **13,** 1, 43–51, Mar. 1960.

Capillary wave-damping experiments were made to determine the relative effects of high- and low-pressure surface films (cetyl alcohol) compared with clean water. Although the matter has been treated theoretically, there are few quantitative data available and tests in a small ripple tank 30 cm × 35 cm × 3 cm were productive in this sense. A tuning fork oscillated a rod 49.4 cps at the water surface which in turn generated waves of small height ($\sim 10^{-3}$ cm). Optical measurement of attenuation of wave height, with distance from wavemaker, results in a damping factor for each experimental condition. Theoretical damping of plane ripples is reviewed for the case where viscosity is the controlling factor and for the case where surface films are present. Corresponding damping factors, which depend on kinematic viscosity and group velocity, are derived.

Wave damping is expressed in a graph of height attenuation with distance from wavemaker and in two tables of damping characteristics. In all cases, observed damping exceeds predicted and author speculates on need of additional damping mechanism to complete theory. High-pressure surface films are more effective than are low-pressure surface films. In both cases, formation of surface waves is impeded in addition to the damping process.

Reviewer believes experiment was well conceived and carried out, although waves might have been higher without danger of deformation at lower frequencies. Further experiments are indicated to determine frequency dependence of damping. Such work as this is mostly academic at this time, though application exists in ship-wave interaction (gravity, not capillary waves), where such problems as transfer at sea (fuel, personnel, explosives, etc.) are important.

W. Marks, USA

23. Boisard, P., Solution of the transient flow problem of slightly compressible fluid in a porous medium by means of resistance network (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liquid* **14,** 9, 1107–1146, Sept. 1959.

Author constructs electric analog to solve certain problems of nonsteady flows in porous media. Details of construction are clearly given and useful results obtained. Process has been successfully used at Lacq Profond oil field.

G. Power, England

24. Leigh, D. C., and Sutton, G. W., An analogy between magnetohydrodynamics and heat transfer, *J. Aero/Space Sci.* **27,** 6, 469–470 (Readers' Forum), June 1960.

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 55, 135, 191, 224, 266, 367, 368, 578)

25. Csanady, G. T., Linkage dynamics via linear dependence, *Mach. Design* **32,** 12, 173–177, June 1960.

If the position and the velocities in a mechanism are known and the acceleration of a certain point is x, then that of any other point is $Ax + B$, A and B depending on the position and the velocities. This theorem on "linear dependence" is also valid for the tangential component of the acceleration. For the application an example of a slider-crank mechanism is worked out.

O. Bottema, Holland

26. Denavit, J., and Hartenberg, R. S., Approximate synthesis of spatial linkages, *ASME Trans.* **82** E (*J. Appl. Mech.*), 1, 201–206, Mar. 1960.

A general method, based on the approximate method of Freudenstein for plane linkages, is given for the synthesis of four-bar space linkages required to develop given functions. Method is applicable provided that an analytical expression relating the input and output can be derived and that this equation can be expressed in a particular form amenable to solution. The displacement equation analysis can be performed by methods previously published by authors and this paper shows how, in important particular cases, equations thus derived can be expressed in required form for computation. Substitution of coordinates of required accuracy points yields a set of equations which can be solved, probably on a computer, for the parameters of the desired mechanism. Authors consider three particular mechanisms and give examples of solutions for each.

Paper is highly commended; application of method to Bennet linkage also would be interesting.

R. H. Macmillan, Wales

27. Bjerninger, S., Investigations into braking of tractors and trailors, Trans. Roy. Inst. Technol., Stockholm, no. 138, 136 pp., 1959.

Experimental and theoretical investigations are reported of factors affecting the stopping ability and course stability of rubber-tired agricultural tractors and trailers. Braking tests were made with tractors and trailers on horizontal roads and slopes in order to compare various types of braking systems and to investigate the influence of brake-application power, choice of braked wheels, type and mass of trailers, load distribution, road conditions, etc., on braking. The effects of speed, overrun force, and coefficient of friction on the equilibrium and rear-wheel skid of the tractor, and on the possibilities to counteract a jackknifing tendency and recover directional tendency are studied by means of a simplified analysis.

F. Jindra, USA

28. Filonenko, G. G., The motion of a wheel rolling on an elastic rail (in Russian), *Prikl. Meckhanika* **4,** 2, 182–191, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4733.

The solution is carried through of a system of differential equations with periodic coefficients describing the motion of a wheel with a spring-mounted mass moving on an elastic rail. The regions of parametric resonance are determined; the first region corresponds to velocities of 30.941 m/sec $< \nu <$ 31.059 m/sec; the second, to 61.764 m/sec $< \nu <$ 62.23 m/sec. It was established that, in the first region, loss of contact between wheel and rail occurred. The maximum deflection of the rail caused by impact forces in the first region of parametric resonance is three times greater than the static.

K. S. Kolesnikov

Courtesy Referativnyi Zhurnal, USSR

29. Stevens, J. E., Slip coefficient for a tire, *J. Aero/Space Sci.* **27,** 4, 305–306 (Readers' Forum), Apr. 1960.

Author attempts to explain phenomenon of deviation from pure rolling conditions of an elastic wheel under applied torque, in which simple relations between forward velocity and rolling radius no longer hold. The mechanism postulated is that of a continuous slip in the contact patch of elastic wheel, slip velocity being only dependent on meridional position and reversing sign in contact patch to provide near-cancellation of two large forces. Reviewer is not aware of experimental evidence confirming idea of continuous slip, particularly in longitudinal directions only. However, this idea may be applicable under very slippery conditions.

S. K. Clark, USA

30. Carrier, G. F., and Miles, J. W., On the annular damper for a damper for a freely precessing gyroscope, *ASME Trans.* **82** E (*J. Appl. Mech.*), 2, 237–240, June 1960.

Paper deals with a symmetrical gyroscope on which no external forces are exerted. The moment of inertia is largest about the axis of symmetry which precesses at a very small angle of nutation.

The authors suggest checking this precession by means of a small amount of liquid contained in an annular cavity circling the axis of symmetry, but not at the level of the center of mass. The small quantity of liquid does not directly affect the gyroscopical motion but absorbs energy during precession. The authors suppose, but do not prove, that the energy absorption will affect precession only and check it.

To obtain the length of time required to stop precession, authors calculate the difference between the energies of the gyroscope at a given angle of nutation and at angle of nutation zero, assuming the speed of spin is conserved. This difference is then divided by the rate of energy absorption in the liquid.

Paper depicts the various forms taken on by the liquid's surface at different angles of nutation (always small), the liquid more or less filling the cavity.

Numerical example is given for a very slowly moving gyroscope.

This mathematical paper induces the reader to develop further the control of the revolution of gyroscopes by means of internal mechanisms.

J. Boas Popper, Israel

31. Misnikov, P. V., A new method for separating one class of integrable cases of motion from the general problem on the rotation of a heavy solid body about a fixed point (in Russian), *Ucben. Zap. MGU, Mekhanika* **5,** 172, 143–162, 1954; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2238.

The basis of this method is an investigation of the plane together with the moving solid body containing the vector of the momentary angular velocity and the vector-moment of the quantity of motion of the body (the plane being the characteristic plane in the terminology of the author). The author finds numerous known particular cases of integrability of Euler's equations by making different assumptions regarding the location of the center of gravity of the body in relation to the principal planes of inertia of the point of support, and on the further assumption that the characteristic plane passes, during the whole time of the motion, through the center of gravity.

Note by the abstractor: Lack of clarity should be pointed out in the exposition of various parts of the study and in the occasional unemphasized difficulties encountered because of the complexity of analysis of the equations connected with the problem. For instance, there is no clear-cut statement to the effect that the assumption regarding the passage of the characteristic plane through the center of gravity during the whole time of motion of the body appears to be a requirement for the existence of the integral $\Sigma (B-C) qrx_0 = 0$ in Euler's equations; that equation (Z) should naturally be treated without matrices, and so forth.

L. N. Sretenskii

Courtesy Referativnyi Zhurnal, USSR

32. Bismut, M., Dynamics of flight: Resonance of spinning missiles (in French), *Recb. Aéro.* no. 74, 3–11, Jan./Feb. 1960.

Theoretical study of dynamics of spinning axially symmetric unguided missiles. Author studies conditions under which a resonance occurs between roll and transverse oscillations induced by perturbations in angle-of-attack or small missile asymmetry. Analog solutions of the equation of motion are made for two types of flight; resonance in level flight and in ascending or descending trajectories.

W. C. Griffith, USA

33. Pozharitskii, G. K., On the stability of permanent rotations of a rigid body with a fixed point under the action of a Newtonian central force field, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 4, 1134–1137, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Stability criteria for permanent rotations of a rigid body with one point fixed are established. The analysis shows that the axes of all permanent rotations coincide with the axis directed from the center of forces to the fixed point and in the moving system are distributed over a cone which is analogous to the Staude cone in the problem of the motion of a heavy rigid body with one fixed point in a uniform gravitational field. Routh criteria give sufficient conditions for conditional stability, while, according to Lyapunov, these conditions in the case of noncyclic coordinates are also sufficient for unconditional stability. Inequalities are developed which in general single out the stable permanent axes. A study of the general inequalities is not performed, but a simple example for a rotationally symmetric body is presented.

A few typographical errors, most of them obvious, occurred in the printing of the translation of the paper.

M. I. Yarymovych, USA

34. Chzhan Sy-In, On estimates of the solutions of systems of differential equations of the accumulation of disturbances and the stability of motion over a finite time interval, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 4, 920–933, 1959, (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author develops conditions of stability of the motion of a system with n degrees of freedom over a finite time interval if that motion is described either by the homogeneous linear system of D.E.

$$\dot{x}_s = p_{s1}(t)\, x_1 + \ldots + p_{sn}(t)\, x_n \ldots, \quad s = 1, \ldots, n \qquad [1]$$

with known functions $p_{sr}(t)$ and given initial conditions for the x_s, where especially the case of slowly changing coefficients

$$p_{sr}(t) = C_{sr} + E f_{sr}(t), \quad C_{sr} = \text{const.} \qquad [1']$$

is considered, or by the inhomogeneous system of D.E.

$$\dot{x}_s = p_{s1}(6)\, x_1 + \ldots + p_{sm}(t)\, x_m + R_s(t), \quad s = 1, \ldots, n. \qquad [2]$$

Here the functions $R_s(t)$ describe continuously acting disturbances subjected to certain restrictions. In order to obtain stability conditions author transforms the system [1] with a linear transformation

$$x_s = b_{s1}(t)\, y_1 + \ldots + b_{sn}(t)\, y_n, \quad s = 1, \ldots, n \qquad [3]$$

into the canonical form for the y_s. Using the function

$$V = e^{-\alpha(t)} (y_1^2 + \ldots + y_n^2), \qquad [4]$$

where $\alpha(t)$ is not yet determined, author shows that the derivative dV/dt becomes negative if $\alpha(t)$ satisfies a certain inequality. From this sufficient condition for the stability of motion of the y_s involving conditions for the x_s of [1] in the form

$$|x_s(t)| \leq x_s^0, \qquad [5]$$

where $|x_{s0}| \leq x_s^0$, $t_0 \leq t \leq t_1$, are obtained. Then the special system [1'] is considered. Of course the stability condition in this case is less complicated. After this the method is extended to the system [2]. Then a brief outlook is given to nonlinear systems of D.E. Finally, some examples are numerically computed.

R. M. G. Muller, Indonesia

35. Duboshin, G. N., Differential equations for the forward rotational motion of mutually attracted solid bodies (in Russian), *Astron. Zh.* **35,** 2, 265–276, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4686.

This is an investigation of the motion of several solid bodies of finite dimensions, the primary constituents of which are being mutually attracted in conformity with Newton's law. The location of each body is determined relative to an absolute system by means of three coordinates of its center of inertia and by three Euler angles. The equations for the motion are in Lagrangian form. It is shown that the system has ten first integrals, analogous to the classical integrals of the general problem of celestial mechanics on the motion of a system of mutually attracting material points. If k bodies (from $n+1$ bodies) possess the property of spherical symmetry of mass then the system will have another $3k$ first integrals; if however the k bodies have axes of dynamic symmetry then the system will have k supplementary first integrals.

The question is then taken up regarding the division of the system of differential equations into two independent systems, each of which is capable of determining separately the forward and rotational motions. It is demonstrated that if the central ellipsoids of inertia of all the bodies taking part in the system degenerate in the sphere then a complete division (in the given sense) will occur in the differential equations of the motion. In this case each body rotates round an unchanging axis passing through its center of inertia at a constant angular velocity. In other cases complete division of the equations of motion is only possible by adopting some approximations. In particular, if the terms of the first order relative to the reverse distances are retained in the equations of motion then the differential equations for the motion divide fully; in this case each body rotates by inertia. If, however, only terms of the second and third orders relative to the reverse distances are retained then the equations for the forward motion form an independent system, while the equations for the rotational motion will contain coordinates of the mass centers, which can be investigated as known functions of time. Differential equations for the motion on movable axes are derived, and two cases are examined: (1) a new system, in which a study is made of the motion having its origin in the center of inertia of one of the bodies and gradually changing position parallel to the absolute axes; (2) a new system of coordinates coinciding with the principal central axes of inertia of one of the bodies.

D. P. Merkin

Courtesy Referativnyi Zhurnal, USSR

36. Kuz'min, P. A., The theory of permanent rotations (in Russian), *Izv. Vyssb. Uchebn. Zavedenii, Aviats. Tekbn.* no. 2, 16–19, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4706.

The stability is investigated of the rotation of a solid body round a vertical permanent axis. This problem has been solved previously by V. V.Rumyantsev [*Prikl. Mat. Mekh.* **20,** 1, 51–66, 1956], but differing from that solution the author refers the equations of motion to a system of coordinates non-coincident with the principal axes of inertia. The linear integral-bundle of N. G. Chetaev is used for Lyapunov's function. Satisfactory conditions for stability are found which, being expressed through the coordinates of the center of gravity and the directing cosines of the vertical in the principal axes, give two inequalities equivalent to the original. These inequalities are equipollent to the conditions obtained by V. V. Rumyantsev.

L. M. Markhashov

Courtesy Referativnyi Zhurnal, USSR

Book—37. Meshcherskii, I. V., A collection of problems on theoretical mechanics (for collegiate students), 24th ed. (in Russian), Moscow, Gos. Izd-vo Fiz.-Matem. Lit., 1958, 384 pp. + illus. 8 r 60 k; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4700.

38. Cruickshank, A. J. O., A tensor description of periodic phenomena, Parts I, II, III, *Matrix Tensor Quart.* **9,** 2, 47–52, Dec. 1958; **9,** 3, 83–87, Mar. 1959; **9,** 4, 98–101, June 1959.

In electric circuit theory it is customary to represent periodic functions by Fourier series. Author proposes "ordinate representation" of periodic functions, $f(t) = \Sigma_k f(t_k)\, r(t - t_k)$, where the t_k are equally-spaced abscissae, $f(t_k)$ the corresponding ordinates, $r(t)$ a function such that $r(0) = 1$, $r(t_b - t_k) = 0$ for $b \neq k$. Author shows that, for his particular choice of $r(t)$, impedances Z can be represented by cyclic matrices, $Z = (Z_{bk}) = (Z_{b-k})$, and states that therefore the ordinate representation simplified calculations, as compared to the Fourier representation, in the case of nonlinear circuits. P. M. Treuenfels, USA

39. Caughey, T. K., Classical normal modes in damped linear dynamic systems, *ASME Trans.* **82** E (*J. Appl. Mech.*), 2, 269–271, June 1960.

An analysis of the conditions under which a damped linear system possesses classical normal modes is presented. It is shown that a necessary and sufficient condition for the existence of classical normal modes is that the damping matrix be diagonalized by the same transformation that uncouples the undamped systems. Sufficient though not necessary conditions on the damping matrix are developed, and it is shown that Rayleigh's solution is a special case of the treated theory.

From author's summary by L. Caprioli, Italy

40. Shevelo, V. M., Approximate investigations of vibrational systems (in Russiam), *Dop. Akad. Nauk URSR* no. 6, 609–612, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4708.

An attempt is made to widen the approximate method for investigating vibrational systems proposed by A. Yu. Ishlinskii [see *Prikl. Mekh.* **2,** 2, 152–158, 1956] to include vibrational systems capable of description by means of ordinary differential equations of the third order with variable coefficients. The results obtained were used for the determination of the criteria of damping of the dynamic forces in an imponderable filament of variable length with a load at the end and with the linear principles of aftereffect and relaxation operating. M. E. Temchenko

Courtesy Referativnyi Zhurnal, USSR

41. Paslay, P. R., and Gurtin, M. E., The vibration response of a linear undamped system resting on a nonlinear spring, *ASME Trans.* **82** E (*J. Appl. Mech.*), 2, 272–274, June 1960.

The steady-state, undamped-displacement-amplitude response of a linear system on a single nonlinear spring due to a force excitation which varies sinusoidally with time is investigated. The force-displacement relation of the spring is $F = k(x + x^3)$. The Fourier component of the displacement-amplitude response and its third harmonic are considered.

From authors' summary by L. Caprioli, Italy

42. Rosenberg, R. M., Normal modes of nonlinear dual-mode systems, *ASME Trans.* **82** E (*J. Appl. Mech.*) 2, 263–268, June 1960.

Author considers a nonlinear two-degree-of-freedom mechanical system consisting of two masses connected to the two anchor springs and coupled to a third spring. The forces of all the springs are odd polynomials in the deflections.

Normal-modes (or modal-relations) for a linear or nonlinear system are defined independently of the natural frequencies. Author shows that a knowledge of the defined normal-modes reduces the (linear or nonlinear) two-degree-of-freedom problem to two systems, each in only a single degree of freedom, and that the determination of the frequency-amplitude relations can be reduced to a quadrature.

Paper treats moreover the straight and curved modal-relations for some important two-degree-of-freedom nonlinear systems and the maximum-minimum properties of the modal-relations of a linear or nonlinear eigenvalue problem. L. Caprioli, Italy

43. Szulkin, P., On forced vibrations in a non-linear system with many degrees of freedom, *Bull. Acad. Polonaise Sci. (IV)* **8,** 5, 225–232, 1960.

44. Kauderer, H., Nonlinear vibrations with unsteady excitation (in German), *Ing.-Arch.* **28,** 154–167, Mar. 1959.

This article is devoted to establishing resonance diagrams for undamped oscillators with nonlinear characteristics subjected to various forms of periodical unsteady excitation. The choice of these forms is made so as to conserve a close analogy with the forced oscillations of the same oscillators produced by an harmonic excitation.

Detailed results are developed for Duffing's equation.

The paper also outlines a possible extension of this method to autonomous systems (e. g. Mathieu's d. e.), especially in the so-called parametric excitation. D. Mangeron, Roumania

45. Klotter, K., and Kreyszig, E., Amplitudes of oscillations governed by a modified van der Pol equation, *Quart. Appl. Math.* **18,** 1, 61–69, Apr. 1960.

Paper considers the equation

$$q'' - (\operatorname{sgn} q')(\kappa^2 s)(1 - \beta^2 q'^2) + \kappa^2 f(q) = 0 \qquad (s > 0).$$

By transforming in terms of $\tilde{q} = -(\operatorname{sgn} q')\, q$ and $U = \tilde{q}'^2/\kappa^2$ (a misprint omits the $'$ in the definition of U) and nondimensionalizing, the resulting equation can be solved for the difference in q for successive zeros of U (i.e. $q' = 0$, the end of a swing).

Graphical illustrations of solutions are given, and existence of limiting oscillation amplitudes shown, for $f(q) \propto q^{2m+1}$. Basic solution is extended to more general $f(q)$ as odd functions of q, and further for general $f(q)$ limiting amplitudes are shown to exist having different magnitudes in each direction of swing.

K. H. Griffin, England

46. Morrow, C. T., Random vibration, *J. Acoust. Soc. Amer.* **32,** 6, 742–748, June 1960.

There is, at present, a great interest in random vibration as a special aspect of shock and vibration, especially in relation to effects on equipment. Author explains what is meant by random vibration as opposed to other excitations that might be confused with it, what is involved in random vibration testing, what the corresponding objectives are, why there is controversy about these general subjects, and how some of the controversies may be resolved. From author's summary

Instrumentation and Automatic Control

(See also Revs. 13, 21, 30, 405)

47. Kaltenecker, H., Terminology, purpose, methods and auxiliaries of open loop control techniques (in German), *Regelungstechnik* **8,** 3, 73–78, Mar. 1960.

48. Kosbahn, T., Open loop systems in control engineering (in German), *Regelungstechnik* **8,** 3, 79–84, Mar. 1960.

49. Lefschetz, S., On automatic controls, AFOSR TN 60-230 (RIAS TR-60-9), 6 pp., Mar. 1960.

Author deals with the system $\dot{x} = Ax + F(x) + b \operatorname{sgn} s$, $\dot{s} = c'x - r \operatorname{sgn} s$, where x, b, c, F are vectors, A a matrix, r a scalar. He obtains estimates of the region of stability (of the initial values) by means of the direct method of Lyapunov. The problem is a

generalization of a problem repeatedly considered in the Soviet literature. Numerical results are not given.

W. Hahn, India

50. Anke, K., and Kessler, C., Theory and technique in register control (in German), *Regelungstechnik* **8**, 7, 233–238, July 1960.

51. Abzug, M. J., The transfer function of a spring-tab control, *J. Aero/Space Sci.* **27**, 4, 307–308 (Readers' Forum), Apr. 1960.

52. Zaborszky, J., and Diesel, J. W., A statistically averaged error criterion for feedback-system synthesis, *J. Aero/Space Sci.* **27**, 2, 128–134, 160, Feb. 1960.

For evaluation of the performance of the feedback systems a criterion is proposed in which the measure of the error in performance is averaged with respect to the time of occurrence (or use of the output) and with respect to the ensemble of all inputs assumed. The explicit expression for the criterion in linear single-variable case with mean-square measure of performance is given. This expression is modified by using a complete normalized orthogonal set of functions from which the coefficients of the members could be obtained by minimizing. An illustrative example which does not involve the ensemble averaging was given. A subsequent publication will develop the procedure suitable for the synthesis by using computers.

M. Mesarovik, USA

53. Zubov, V. I., A new method of constructing stability regions for an automatic control system in the space occupied by the permissible values of the parameters, *Automation and Remote Control* **20**, 3, 314–318, Jan. 1960. (Translation of *Avtomatika i Telemekhanika USSR* **20**, 3, 331–334, Mar. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

Matrix methods and a few elementary complex variable transformations are used to determine bounds on the roots of the characteristic equation of a linear system. It is assumed that the differential equations governing the system have been linearized and written in reduced form, i.e. as a set of n linear first-order differential equations $\{\dot{x}\} = [P]\{x\}$ where $[P]$ is an $n \times n$ matrix of coefficients. The characteristic roots λ_i, $i = 1,2,\ldots n$, of this homogeneous equation are transformed onto a complex ρ-plane by $\lambda = (\rho + 1)/(\rho - 1)$, which maps the left half of the λ-plane into the region $|\rho| < 1$ within the unit circle in the ρ-plane. The matrix whose latent roots are ρ_i, corresponding to λ_i, is shown to be

$$[B] = I + 2([P] - I)^{-1}$$

where I is the identity matrix.

The stability criterion that the real part of the λ_i must be negative now corresponds to requiring that the roots ρ_i lie within the unit circle $|\rho| < 1$. The author suggests that in order to ascertain whether this condition is satisfied, one should examine the elements b_{ij}^k of the matrix $[B]^k$ where the power $k = 1,2,\ldots\infty$. Certainly, if the roots ρ_i lie within the unit circle, $b_{ij}^k \to 0$ as $k \to \infty$. Subregions of permissible values for the coefficients of P are found by successively imposing the conditions $|b_{ij}^k| \leq \frac{1}{n}$, $i,j, = 1,2,\ldots n$, the subregions growing with k and asymptotically approaching the exact allowable region as $k \to \infty$.

In a similar way, other regions in the λ-plane are mapped into $|\rho| < 1$ (e.g. $Re\ \lambda < -\alpha$) and the above test is repeated with a corresponding derived matrix $[\bar{B}]$. No examples are given in the paper, but author mentions that a case was run using a "Strela" computer and values of k of 32, 64, 128,.... No comparison is made between the computer time necessary using this method and that required for an alternate technique, such as simply determining the root loci of $[P]$.

H. E. Lindberg, USA

54. Miyata, F., On the principle of the determination of a transfer function from its empirical data, Part 1, *Bull. Tokyo Inst. Technol.* (*B*) no. 2, 15–20, 1959. (Special Rep. Res. Lab. Precision Machinery and Electronics (P.M.E.) no. 3)

Author proposes a method for determining exactly the transfer function of a given system from its empirical data when the transfer function is a rational function. The procedure consists essentially in obtaining numerically a sufficient number of time derivatives of the function $f(t)$ which is the output of a system when a unit step input $u(t)$ is impressed upon it, and in constructing determinants which establish the order of the transfer function and yield the required constants for the systeml

The presentation is very clear and useful.

V. Chobotov, USA

55. Clauser, F. H., The transient behavior of nonlinear systems, AFOSR TN-60-397 (Johns Hopkins U., Dept. Aero.), 56 pp., Apr. 1960.

It is shown that the classical perturbation procedure for treating nonlinear systems leads to solutions expressed as Fourier-like series with slowly varying coefficients. These slowly varying coefficients contain the information about the long-term behavior of the system. Inconsistently, the classical perturbation procedure expresses these coefficients as power series, a mode of expression which has notoriously poor long-term validity.

An operational procedure is presented for treating oscillations having slowly variable amplitudes and frequencies. An extension of the usual impedance concepts is presented for expressing the frequency characteristics of both linear and nonlinear elements when oscillations with many frequencies are present simultaneously and when these oscillations vary in both frequency and amplitude. From these methods, a perturbation procedure is devised which permits the behavior of systems to be computed with any order of accuracy, using only the algebraic processes which are characteristic of operational procedures. This procedure avoids expressing its results in terms of the local time. Instead, it expresses them in terms of the fundamental characteristics of the oscillations which are present. As a consequence, the final solutions have the much desired long-term validity and they may be used to obtain asymptotic estimates of the behavior of the system. The method is able to treat systems containing nonlinear perturbing elements and elements which are described as moderately nonlinear.

By means of examples it is shown that it is a straightforward process to treat systems to second-order accuracy. This level of accuracy covers a large number of the intercoupling effects that characterize the more sophisticated nonlinear phenomena.

From author's summary by R. J. Kavanagh, Canada

56. Naumov, B. N., Choice of characteristic for nonlinear-rate feedback in position servos, *Automation and Remote Control* **20**, 3, 319–329, Jan. 1960. (Translation of *Avtomatika i Telemekhanika* **20**, 3, 335–346, Mar. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

This paper describes a method which can be used to determine the input-output curve for a nonlinear feedback device such that the output of the total system approaches a pre-assigned time function for a given system input. The output of the linear part of the system, for a given input $F_1(t)$ in the absence of the nonlinear feedback, is first determined, either by calculation or experiment. The final portion of this output, which generally contains considerable overshoot and oscillations, is replaced with a sketched-in curve $X_s(t)$ of "sought response" containing no overshoot and having no derivatives of magnitudes inconsistent with the power capabilities of the system. Another input $\Phi(t)$ is then put into the linear system in addition to $F_1(t)$ such that the response to $F_1(t) + \Phi(t)$ approximates $X_s(t)$. The author sets up a tabular method, using an impulse technique to find the response to $\Phi(t)$, such that the function is determined explicitly as a function of X_s at the discrete sampling points. The function $\Phi(X_s)$ is the desired input-

output curve of the nonlinear device to be inserted between the output and input of the linear system. This method is very similar in principle to that given by Schmidt and Triplett [AMR 8(1955), Rev. 1564].

A numerical example is given, including the entire tabulation necessary to determine $\Phi(X_g)$ for a third-order linear system with one open-loop pole at the origin. A function $\Phi(X_g)$ is first determined for a step input, and then replaced by a straight-line approximation $\bar{\Phi}(X) = ax + b$ (where a and b are positive constants) which is shown to give a response quite close to $X_g(t)$. The function $\bar{\Phi}(x)$ is provided by a diode circuit such that the b varies in proportion to the amplitude of the step input $F_1(t)$. No data is provided to show how well the provision for variable b acts to make the response near optimal for varying step amplitudes. The author does not discuss whether or not there is a range of initial velocities and accelerations for which the system can become unstable (see, e.g., "Studies of second- and third-order contactor control systems," by I. Flügge-Lotz et al, NASA TN D-107, p. 59, Oct. 1959].

H. E. Lindberg, USA

57. LaSalle, J. P., The bang-bang principle, AFOSR TN 59-1142 (RIAS, Baltimore, Md. TR 59-5), 16 pp., Nov. 1959.

As many known systems make the best use of available power by means of relays, this paper mathematically proves that for so-called "Proper control systems" "bang-bang" steering actually is optimal. (Proper control systems are those that can be steered from any state to another as rapidly as desired, were there no constraints on steering variables.)

J. M. Loeb, France

58. Still, W. L., Separate signal from noise with probability filters, *Control Engng.* **7,** 3, 147-151, Mar. 1960.

A nonlinear feedback arrangement is proposed for the extraction of a signal from noise. The error signal is first put through an instantaneous nonlinear device with the input-output characteristic $y = \varepsilon p(\varepsilon)$ (y output, ε error signal, $p(\varepsilon)$ probability density of error signal), then integrated and fed back. The arrangement is intended to detect differences in the statistics of signal and noise which escape linear filters. Simulations to air-to-air missile guidance are cited in support of this notion. Further improvement is said to be obtained from inserting a dead zone in the above input-output characteristic.

Article is sketchy and intentionally rather nontechnical. Reviewer considers reasoning and results questionable.

R. F. Drenick, USA

59. Jarominek, W., The equivalence of the Routh-Hurwitz and the Markov stability criteria, *Soviet Phys.-Doklady* **5,** 1, 78-82, July/Aug. 1960. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **130,** 6, 1224-1227, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

60. Margolis, M., On the theory of process adaptive control systems, the learning model approach, AFOSR TN 60-618 (Univ. Calif., Dept. Engng., Los Angeles, Rep. 60-32), 152 pp., May 1960.

61. Vamosh, T., Transfer functions of the steam production of pulverized-coal drum-type boilers (in Russian), *Acta Techn., Acad. Sci. Hungaricae, Budapest* **25,** 3/4, 351-370, 1959.

Aim of paper is to investigate the behavior of economizer tubes for drum-type steam boilers, working under slow and small heat loss fluctuations, by means of the Laplace integral transform.

Supposing constant specific heats and weights, small pressure variations in the fluid and negligible longitudinal conductivity of the tube walls, the heat-transfer equations for the part of the tubes where boiling temperature is not reached are written and reduced to an equation for the fluctuations of the fluids' temperature.

By means of a Laplace transform a transfer function is obtained whose real part is shown as practically constant. The inverse transform shows that the length of the non-boiling liquid column becomes practically constant, after a "critical" time period.

Simplifications made during the calculation are shown to have little influence on the results.

Similar reasoning and the use of the Laplace transform show that in the part of the economizer tubes where boiling takes place the ratio between the fluctuations of the steam output and the heat input tends to become constant with time.

L. G. Hamburger, Roumania

62. Geiss, W., Automation in petro-chemical industry (in German), *Regelungstechnik* **8,** 6, 185-190, June 1960.

63. Raeber, V., Stability of the control of hydroelectric systems (in French), *Bull. Tech. Vevey* **19,** 29-51, 1959.

In first part of article, differential equations of controlled system and regulator are derived either from complete turbine characteristic and characteristic curves of individual elements or are based on theoretical considerations presented in 1958 in a cited paper by L. Borel. The basic equations being linear with constant coefficients, it is possible to apply Laplace transform to obtain transfer function of total system. Stability of system is investigated by means of the Nyquist criterion suitably modified in terms of logarithmic coordinates in order to facilitate solution of given problem. Stability is determined by the following conditions: (1) the phase angle y must be positive for unit magnitude of frequency response; (2) for frequencies greater than that corresponding to unit magnitude, the magnitude must be less than one.

Theoretically derived results are applied to practical solution of a Francis turbine of 65.5-m head, flow of 100 m³ps output of 80,000 hp and speed of 150 rpm. Limits of stability for various time constants and amplication factors are determined. Three types of regulator of angle of guiding vanes are considered: (1) based on changes in speed and its derivative, (2) as in (1) with additional response to changes in energy of medium flowing through turbine, and (3) as in (2) with additional response to changes in rate of change of energy.

Article constitutes a detailed and original solution of the problem of selection of parameters of hydroelectric group in order to ensure stability.

F. Turek, Czechoslovakia

64. Ransford, G., and Rottner, J., The optimization of frequency regulation by Kaplan units taking account of the turbine efficiency curves and grid inherent stability (in French and English), *Houille Blanche* **14,** 6, 762-777, Nov. 1959.

G. Ransford has recently published a series of papers in this journal concerned with hydraulic turbine governing. Taken as a group they are a considerable contribution to research in this field. This paper should be read in conjunction with a second part appearing in the same journal, **15,** 1, pp. 22-30, 1960, which gives a numerical example of the application of method. Reading of earlier papers [*Houille Blanche* **13,** 3, 205-228, 1958 (AMR **11** (1958), Rev. 4839); **14,** 1, 23-46, 1959 (AMR **13**(1960), Rev. 574)] also throws light on authors' techniques. In their first paper, authors determine the optimum operating factors of a Francis turbine, taking account of both favorable grid inherent stability factor and adverse turbine efficiency curves. Mean square error in frequency, I, is minimized for a sudden load change using the Wiener-Krasovsky criterion which gives this quantity directly in terms of the coefficients of the third-order governing equation. Salient parameters of the transient response are also determined. Second paper treats similarly a Pelton wheel, but analysis is complicated further by supply pipe elasticity. Numerical examples, obtained by use of authors' published curves, are given.

Paper reviewed completes cycle by a study of Kaplan turbine. Blades respond slowly in comparison with gate closure effects so only latter is considered. Two new parameters must now be introduced to account for the slopes of the curves in the efficiency

diagrams. I can now be evaluated as function of these parameters for typical values of remaining variables. Technique enables the governor design to be determined from given permissible frequency variations for a certain load variation.

Value of article, which contributes a significant new and practical technique, is much enhanced by its second part where worked example does much to clarify its obscurities. Computer has been used to obtain valuable dimensionless tabulations of results.

It appears to reviewer that techniques expounded might well be applied to linear servo design in many other fields and it is hoped that their publication in a journal little seen by servo engineers will not delay their widespread study.

R. H. Macmillan, Wales

65. Ashkenas, I. L., and McRuer, D. T., Optimization of the flight-control, airframe system, *J. Aero/Space Sci.* **27,** 3, 197-218, Mar. 1960.

The system composed of a flight control and airframe is very difficult to analyze because it involves a great number of adjustable parameters. Ordinarily in such situations it is the controller which is to be synthesized. Authors took an advanced viewpoint and considered the influence of the changes in the airframe parameters on the over-all performance of the system. As the method of analysis, they used graphic-analytical root-locus technique. The results obtained show clearly the advantages of selecting the airframe parameters. Study of a simplified example gives an excellent insight to the influence of the variation in the parammeters on the performance of the system. The reviewer is of the opinion, however, that in a given situation in process of optimization, one should use the modern analytical method combined with the computer techniques rather than graphic-analytical root-locus technique.

M. Mesarovic, USA

66. Aminatov, I. N., and Tikhonov, V. I., The influence of fluctuations on the operation of an automatic range-finder, *Automation and Remote Control* **19,** 4, 318-326, Feb. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 4, 325-333, Apr. 1959 by Instrument Society of America, Pittsburgh, Pa.)

Article first describes automatic range-finder apparatus consisting of (1) a time detector; (2) time modulator, and (3) a differential detector. Basic task of apparatus is accurate placement of selector pulses from modulator (2) on reflected pulses registered in (1). Three basic assumptions in constructing proposed automatic range-finder model are discussed. Next is considered effect of noise due to small fluctuations (in the form of a stationary random process) from the receiver, and closed-system stochastic difference equation for the error time signal is derived. General expressions for mean value and dispersion of the solution of this equation are found and also for the case where fluctuations are Gaussian with given correlation function. Finally the region of stability is discussed and a numerical example given. Further problems relating to the generalization of the theoretical model presented in the article are mentioned.

A. H. Zaludova, Czechoslovakia

67. Hoffman, C. W., A radio control and powering system for free-running models of surface ships, David W. Taylor Mod. Basin Rep. 1359, 94 pp., Feb. 1960.

68. Maebashi, Y., The continuous recording method of thickness testing using an ultrasonic thickness tester, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14-15, 1958; Japan Society for Testing Materials, Kyoto, 1959, 227-230.

Author employs an ultrasonic thickness tester in conjunction with a 35-mm camera to continuously record resonance waves displayed on an oscilloscope screen. The technique requires that film advance be synchronized with thickness probe scanning. Lines are generated on the film by photographing the screen through a slit. Sample records are shown for a stepped and sloped plate, as well as gas cylinders. The author describes the advantages of his method over the use of a conventional recording galvanometer. Reviewer believes that a description of the method of film synchronization with ultrasonic probe scanning would be most helpful.

M. B. Hollander, USA

69. Ikebe, Y., and Nakano, K., Frequency response recorders, *Bull. Tokyo Inst. Technol.* (*B*) no. 2, 21-31, 1959. (Special Rep. Res. Lab. Precision Machinery and Electronics (P.M.E.), no. 3)

Analysis is presented of two methods of recording the frequency response of elements or systems for automatic control. Amplitude ratio and phase shift are obtained by recording the output signal on a polar chart with sinusoidal input. The methods differ in using (1) a rotating recorder disk and (2) electrical multipliers and an X-Y recorder or oscilloscope. The advantages claimed are ease of operation and greater accuracy than obtainable with other methods. Reviewer believes benefits of polar recording would be significant only if large number of components were to be tested.

D. W. Appel, USA

Tables, Charts, Dictionaries, etc.

(See Revs. 208, 554)

Elasticity

(See also Revs. 4, 28, 90, 93, 100, 124, 127, 133, 134, 135, 136, 138, 144, 147, 149, 152, 154, 155, 156, 158, 170,190, 200, 224, 228, 229, 233, 414, 415, 534)

70. Walker, B. A., Distribution of shear stress in a box beam, *Engineer, Lond.* **209,** 5448, 1067-1069 (Technical Contributors Section), June 1960.

Since consideration is given only to thin-walled structures, author can express shear flow round symmetrical box section in simple form with respect to unknown shear stress at arbitrary origin on section, here mid-depth of outer web. Unknown stress is determined by minimizing shear energy. Starting at arbitrary origin it is then possible to find shear stresses throughout section by forward integration. Expressions so derived for a two-cell section with webs of equal thickness show that shear stresses in center web are not equal to those in outer webs but are in fact 20 to 30% greater.

It is important to remember assumption of uniformly applied bending moment across the width of box. This would not hold, for example, for point load placed a distance from section equal to or less than width of box.

Problem would be complicated with thick webs by cross bending but application of author's findings, being simple, would be useful for first approximation to shear stresses in such cases.

G. Little, England

71. Hetenyi, M., A method of solution for the elastic quarter-plane, *ASME Trans.* **82** E (*J. Appl. Mech.*), 2, 289-296, June 1960.

It is shown in this paper that for given loads on the elastic quarter-plane the prescribed boundary conditions can be fulfilled by repeated superposition of known solutions for the elastic half-plane. This leads to a sequence of infinite integrals of a simple recursion pattern. The solution is exact, since the sequence may be continued to obtain any required accuracy. Solutions are derived for three types of boundary loads: concentrated normal force,

concentrated tangential force and partially distributed uniform loading.

From author's summary by V. Kopriva, Czechoslovakia

72. Shen, M.-K., An extension of Maxwell's reciprocal relations (in German), *Ing.-Arch.* **27,** 5, 350–351, 1960.

Assumed is a rigidly supported body for which the law of superposition is valid. It is shown that for the displacements δ_{21} and δ_{12} of two points 2 and 1, respectively, caused by the forces P_1 and P_2 respectively, there always exist two systems of principal directions of interchange forming two systems of rectangular axes. These two systems can be characterized as follows: (1) Two forces P_1 and P_2 of equal size which are similarly associated to these systems cause two displacements δ_{21} and δ_{12}, respectively, which are always similarly associated to the same systems and which are of equal size. (2) The displacements δ_{21} and δ_{12} caused by two forces of equal size P_1 and P_2, respectively, which lie in the principal directions of interchange, lie in the same directions and are of equal size. F. Chmelka, Austria

73. Gravesen, S., Elastic semi-infinite medium bounded by a rigid wall with a circular hole (in English), *Bygnsstat. Medd.* **30,** 3, 93–111, Dec. 1959.

The problem of a semi-infinite elastic medium in contact with an infinitely rigid plane (plate) containing a circular hole and loaded "through" this hole is analyzed. The two limiting cases of zero friction and infinite friction at the interface, between the two regions, are investigated. For the case of infinite friction, zero displacement of the elastic surface in its plane is also required for the surface within the circular hole. It is assumed that stresses can be transmitted between the rigid cover plate and the elastic medium, i.e., contact is maintained. This latter condition is satisfied for the three loadings analyzed in the report.

The three example problems analyzed are: (1) a single vertical force at the center of the hole, (2) a circular line load applied within the hole, and (3) a uniform load distributed throughout the region of the hole. A. L. Ross, USA

74. Cvetkov, B., Resultant tension at an opening in a uniaxial compressive stress field (in German), *Bauingenieur* **34,** 12, 476–477, Dec. 1959.

This is a technical note added to the paper of Dr. R. Hiltscher and B. Pant, published under the same title in *Bauingenieur* **32,** 12, 470–474, 1957. In the cited paper, authors determine the resultant tension at the neighborhood of an opening in a uniform uniaxial compression field. They treat two principal cases, i.e. (a) rectangular holes (experimentally, by using classical methods of photoelasticity) and (b) elliptical holes (by applying the theoretical solution of K. Wolf for the determination of the tensile stress and by integrating graphically along the principal axis of the field).

In present paper author summarizes the above-mentioned paper and indicates the difficulties of such graphical procedures. In order to overcome this difficulty, he applies the well-known theory of analytic functions with complex variables for the solution of two-dimensional problems of elasticity, introduced by the Russian school. He determines, in this way, the total resultant tension of elliptic holes for various sizes of the ellipse.

P. S. Theocaris, USA

75. Sopowith, A. D., Transverse shear stiffness for the double "V" corrugated-core sandwich panel, *Aero/Space Engng.* **18,** 9, 53–56, Sept. 1959.

The elastic constant representing the transverse shear stiffness for the double-"V"-type corrugated core sandwich is predicted by adapting the principle of Libove and Hubka. Simplification of the original method is achieved by ignoring the component of deflection with an error of less than one per cent. Predicted values are substantiated by test. Formulas and charts to evaluate the constant are included. A. G. H. Dietz, USA

76. Nomura, Y., On the stiffening of the edge of the hole in an orthogonally aeolotropic plate with a circular hole: Stiffened with a flanged coaming plate and with the double stiffening plates, *Bull. JSME* **2,** 6, 277–285, May 1959.

Continuation of previously reported work [see AMR **12**(1959), Rev. 4319]. Numerical results are obtained for plate of Mongolia oak and for various coaming plate dimensions and materials.

S. J. Medwadowski, USA

77. Benthem, J. P., and van de Vooren, J., On the stress problem of anisotropic wedges (in English), Nat. LuchtLab. Amsterdam NLL-TN S. 537, 31 pp., Feb. 1959.

Wedges of anisotropic material are subject to surface tractions and to forces and couples at their apexes. The problem is two-dimensional. The author uses oblique coordinate axes parallel to the sides of the wedge and finds the equation satisfied by the Airy stress function. The mathematics of the solution is very complicated, but the technique may be of interest to theoretical anisotropic elasticians. D. R. Bland, England

78. Tolokonnikov, L. A., Finite plane deformations of an incompressible material, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 1, 195–210, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

A plane strain elasticity theory for large deformations of an incompressible medium is developed. Compatibility conditions for displacements and rotations are formulated in terms of invariant deformation characteristics, which are reducible to the Saint-Venant conditions for small deformations. A stress function, which satisfies transformed equilibrium equations, is introduced in terms of whose derivatives the invariant true stress characteristics are expressed. The mathematical formulation of the problem is presented in a compact form by means of complex variables.

Two specific nonlinear physical laws of change of shape are studied, and solutions are found by successive approximations where every step reduces to the solution of the classical biharmonic problem. As an example the stress concentrations near a circular cylindrical cavity are studied.

M. I. Yarymovych, USA

79. Lisowski, A., Failure types of rock cubic specimens in the light of the theory of elasticity (in English), *Bull. Acad. Polonaise Sci.* (IV) **7,** 5, 341–351, 1959.

Approximate stress distributions in a rectangular elastic test specimen compressed between rigid platens are obtained from the plane-stress equations by method of finite differences. Friction is first assumed to prevent any relative motion of points in contact with platen. Solution leads to maximum shear stress on interface at corner of specimen. This stress is then supposed to overcome friction and new solution is obtained with unit at corner free to slip relative to platen. Third solution corresponds to two units free to slip. Fourth solution corresponds to third with addition of a crack normal to platen between first and second units. Author concludes that if friction prevents horizontal slipping the specimen is subjected only to compressive stresses. On maximum linear strain theory first failure is expected to be by separation of wedges from sides of specimen. If slipping occurs at corners tensile stresses result, leading to vertical cracking and failure of the specimen at lower loads than for no slipping.

Author's results for stress component parallel to loading direction are qualitatively similar to experimental results given by E. G. Coker and L. N. G. Filon ["Photoelasticity," Cambridge, 1957, pp. 583–588] but stress concentrations found at corners of specimen are much less pronounced. W. M. Gray, Canada

80. Solyanik-Krassa, K. V., Elastic equilibrium of bodies of revolution (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **26,** 113–136, 1958.

Stresses and deformations are determined for solid bodies of revolution loaded on their surface by radial, tangential and axial forces in the form of trigonometric series according to angle φ. The edge conditions on the bodies' faces are fulfilled in the meaning of Saint-Venant. The state of stress of the body of revolution is expressed by means of three functions satisfying a second-order differential equation the integrals of which are given in the form of Bessel functions. Several examples are quoted of the solution of circular cylinders subjected to linearly varying radial and axial load. The solution presented can be extended to include hollow cylinders loaded axially according to any arbitrary power law. J. Valenta, Czechoslovakia

81. Han, L. S., An approximate analysis of the influence of aerodynamic heating and initial twist on the torsional stiffness of thin wings, *ASME Trans.* **82** E (*J. Appl. Mech.*), 2, 332–334, June 1960.

Approximate formulas are derived by a "fiber-stress" concept for calculating the influence of initial twist and chordwise temperature differences on the torsional characteristics of large-aspect-ratio, thin wings. Typical moment-twist curves are presented and discussed to define areas of instability. Identical formulas can be derived more rigorously and easily by application of a variational principle used for this purpose in AMR 11(1958), Rev. 413 [NACA TN 4067, 1957, superceded by NACA TR 1361, 1958]. R. R. Heldenfels, USA

82. Johns, D. J., Thermal stresses in a long circular shell with axial temperature variation, *J. Aero/Space Sci.* **27,** 5, 393–394 (Readers' Forum), May 1960.

An analytical solution is obtained for a long (semi-infinite) circular cylinder stiffened by a bulkhead at one end. An axial temperature distribution is prescribed in the shell and an arbitrary radial temperature distribution in the bulkhead.

J. G. Eisley, USA

83. Forray, M., Table for thermal stresses in rings, *J. Aero/Space Sci.* **27,** 6, p. 478 (Readers' Forum), June 1960.

84. Muki, R., and Sternberg, E., On transient thermal stresses in viscoelastic materials with temperature-dependent properties, Brown Univ., Div. Engng. TR 18 (Contract Nonr 562(20) (NR-064-424)), 66 pp., June 1960.

This paper deals with the quasi-static analysis of transient thermal stresses in the linear theory of homogeneous and isotropic viscoelastic solids with temperature-dependent physical characteristics. The underlying constitutive law rests on the temperature-time equivalence hypothesis according to which a uniform temperature change affects the viscoelastic response of the material through a corresponding uniform shift of the logarithmic time scale. If the temperature varies with time, the preceding hypothesis implies a dependence of the instantaneous stresses upon the entire temperature history.

From authors' summary

85. Parkes, E. W., The stresses in an elasto-plastic bar subjected to a sudden change of surface temperature, AFOSR TN 60-321 (Stanford Univ., Dept. Aero. Engng. no. 89), 20 pp., Jan. 1960.

Author presents a theoretical analysis and calculation of the stresses in an elasto-plastic bar subjected to a sudden change in surface temperature on opposite faces. The analysis assumes Young's modulus, yield stress, coefficient of expansion and thermal diffusivity to be independent of temperature. This assumption allows the analysis to be carried out with only the stress-strain relationship being affected by temperature. Solutions and stress histories have been graphically plotted for maximum thermal stress to yield stress ratios of 1, 2, 3, 4, 5 and 8. Described in detail is the formation and disappearance of yield zones and the elastic behavior of the specimen.

H. Faught, USA

86. Piechocki, W., A certain dynamic problem of thermoelasticity concerning the circular disc (in English), *Bull. Acad. Polonaise Sci.* (IV) **7,** 9, 513–518, 1959.

A heat source varies sinusoidally both with time and with the plane polar coordinate θ. With the dynamic terms included in the equations of motion, the author finds the stress distribution throughout the disk. D. R. Bland, England

87. Kammash, T. B., Murch, S. A., and Naghdi, P. M., The elastic-plastic cylinder subjected to radially distributed heat source, lateral pressure and axial force with application to nuclear reactor fuel elements, *J. Mech. Phys. Solids* **8,** 1, 1–25, Jan. 1960.

The elastic-plastic deformation of a solid cylinder in the presence of a distributed heat source and subjected to a lateral pressure p and an axial force F is considered in detail using Tresca's yield function, its associated flow law, and a linear work-hardening law. The general results are applied to the cylindrical nuclear reactor fuel element in the state of plane strain with a radially distributed Gaussian heat source, acting in its fissionable interior. The solution is expressed in closed form in terms of the exponential integral and the incomplete gamma function and is found to exhibit three stages of plastic deformation. Throughout the deformation the states of stress are found to exhibit regular progression. A numerical example is included. From authors' summary by T. H. Lin, USA

88. Bramble, J. H., and Payne, L. E., On the continuation of solutions of the equations of elasticity by reflection, AFOSR TN 60-903 (Univ. Maryland, Inst. Fluid Dynamics and Appl. Math. TN BN-217), 8 pp., Aug. 1960.

It is shown that solutions of the equations of elasticity may be continued by reflection across a spherical boundary whenever an arbitrary linear combination of the normal displacement and normal surface traction and an arbitrary linear combination of tangential displacements and tangential surface tractions vanish on the spherical surface. From authors' summary

Viscoelasticity

(See also Revs. 125, 172, 201, 235, 272, 414, 510)

89. Mase, G. E., Behavior of viscoelastic plates in bending, *Proc. Amer. Soc. Civ. Engrs.* **86,** EM 3 (*J. Engng. Mech. Div.*), 25–39, June 1960.

In this paper, the behavior of flat viscoelastic plates is studied. The basic differential equations are established using the operator concept and the solutions are obtained by application of the Laplace transform. Two classes of problems are considered. The quasi-static deflection of laterally loaded plates is obtained in terms of the associated elastic deflection of a similar plate. Plate moments for this case are also included and compared with those of the elastic case. The second class considered is that of the dynamic response of simply supported rectangular plates under no load. Here, inertia forces due to deflection are taken into account and the free vibrations of a Maxwell and Kelvin-type plate are given. Throughout the work physical constants of the viscoelastic medium are assumed to be constant. The reviewer is of the opinion that the Galerkin method can well be used for treatment of such problems. M. M. Stanisic, USA

90. Biot, M. A., On the instability and folding deformation of a layered viscoelastic medium in compression, *ASME Trans.* **81** E (*J. Appl. Mech.*), 3, 393–400, Sept. 1959.

Author considers infinite layer of material embedded in infinite medium of other material. Folding of layer is studied under compressive load parallel to layer. Cases are considered where either layer or medium is viscous or viscoelastic.

Folding of layer is shown to occur when load is between upper and lower critical limits. Dominant wavelength of folding, for which folding is maximum under given load, does not depend on load for case of two incompressible viscous solids or, in general, for case of two materials with same relaxation time.

Thermodynamic discussion of incremental stress-strain relations in nonlinear rheology indicates distinction to be made between thermodynamic systems in vicinity of equilibrium and in steady state of flow. B. Bernstein, USA

91. Green, A. E., and Rivlin, R. S., The mechanics of nonlinear materials with memory, Part 3 (in English), *Arch. Rational Mech. Anal.* **4,** 5, 387–404, Mar. 1960.

The materials considered are such that the stress at an instant of time is a function of its time derivatives and the gradients of displacement, velocity, acceleration, etc., at a number of instants in a preceding time interval. Authors examine in full generality the limitations on the constitutive equation if it is to be unaffected by a simultaneous rotation of the body and reference system. Further simplifications, arising from certain analytic restrictions, are discussed at length. Relations with previous theories are pointed out, in particular Rivlin and Ericksen [*J. Rational Mech. Anal.* **4,** p. 323, 1955; AMR **8**(1955), Rev. 3656].

R. Hill, England

92. Corneliussen, A. H., and Lee, E. H., Stress distribution analysis for linear viscoelastic materials, Brown Univ., Div. Appl. Math, TR 2 (Contract DA-19-020-ORD-4750), 34 pp., July 1960.

When solving by classical methods the quasi-static stress analysis problem for sudden loading of a linear viscoelastic body, it is first necessary to determine the appropriate initial conditions. Methods are developed which make the separate determination of initial conditions unnecessary. Several examples are given and the procedures are justified by an application of the viscoelastic operators in integral form. From authors' summary

93. Hunter, S. C., The rolling contact of a rigid cylinder with a viscoelastic half space, Brown Univ., Div. Appl. Math. TR 3 (Contract NOrd 18594), 26 pp., July 1960.

The problem of a rigid cylinder rolling on the surface of a viscoelastic solid is solved in an approximation in which inertial forces are neglected.

With the introduction of viscoelastic effects, the symmetry associated with the corresponding elastic problem is destroyed, and in particular the cylinder motion is impeded by a resistive force. For a standard linear solid, the resulting coefficient of friction, a function of the rolling velocity V, tends to zero for small and large values of V, and attains a single maximum at an intermediate value.

From author's summary

94. Tao, L. N., The creep deflection of a rivet in double shear, *ASME Trans.* **82** E (*J. Appl. Mech.*), 1, p. 208 (Brief Notes), Mar. 1960.

The creep deflection of a rivet in double shear (considered as a beam) was discussed by Marin [AMR **13**(1960), Rev. 1241]. It is shown in this note that the solution of Marin's problem may be expressed in closed formed in terms of beta functions.

Y. Y. Yu, England

95. Fastov, N. S., Stress relaxation and creep as processes of viscous flow, *Soviet Phys.-Doklady* **5,** 1, 144–147, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130,** 1, 65–67, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

96. Stowell, E. Z., A phenomenological theory for the transient creep of metals at elevated temperatures, NASA TR R-44, 15 pp., 1959.

See AMR **12**(1959), Rev. 2265

97. Nikitin, L. V., Some dynamic problems in the theory of plasticity which take into account the influence of the velocity of the deformation (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, Mosk. Fiz.-Tekhn. In-ta, Moscow, 1958; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6695.

Plasticity

(See Also Revs. 4, 85, 87, 96, 97, 123, 143, 209, 213, 218, 228, 234, 239, 240, 242, 248, 414)

98. Rimrott, F. P. J., On the plastic behavior of rotating cylinders, *ASME Trans.* **82** E (*J. Appl. Mech*), 2, 309–315, June 1960.

Author determines strain and stress distributions in a long hollow cylinder based on a deformation theory of plasticity which assumes a power relationship between the second invariants of the stress and strain deviator tensors and accounting for finite displacements and strains. He discusses conditions for failure and determines conditions for instability. In an example, only slight variations were noted in the ratios of principal strains.

R. W. Leonard, USA

99. Ulrich, E., On the problem of the comparative stresses in mechanics of material (in German), *Forsch. Geb. Ing.-Wes.* **25,** 4, 106–114, 1959.

Nowadays it is generally accepted that the comparative stresses computed by means of the distortion-energy hypothesis best predict the actual onset of flow for ductile materials. An accurate investigation of the properties of the stress tensor when considering the octahedral shear stress introduced by A. Nadai shows, however, that this cannot be merely a hypothesis: More than that, the content of the distortion-energy hypothesis represents a strictly valid lemma of the theory of plasticity if one assumes an elastic perfectly plastic isotropic material. The application of the distortion-energy hypothesis for computing of comparative stresses under multidimensional stress conditions of ductile materials thus receives a theoretically sound foundation.

From author's summary by F. W. Wendt, USA

100. Olszak, W., and Zahorski, S., Elastic-plastic bending of a nonhomogeneous orthotropic arch section (in German), *Öst. Ing.-Arch.* **13,** 2, 106–120, 1959.

Previous investigation by Shaffer and House [AMR **9**(1956), Rev. 693] on elastic-plastic stress distribution in a wide curved bar subjected to pure bending is extended to consider nonhomogeneity and aeolotropy. The elastic-plastic properties of the cylindrically orthotropic material are supposed to depend only on radius, which is the only independent variable in the plane-strain problem considered. Beyond the elastic range, ideal plasticity is assumed. Explicit formulas are given for incompressible material.

P. Cicala, Italy

101. Rozenblyum, V. I., On the shakedown theory of elastoplastic bodies (in Russian), *Izv. Akad. Nauk SSSR, Otd, Tekh. Nauk* no. 6, 47–53, June 1958.

Author gives approximate solution of shakedown loads of elastoplastic bodies for following cases: (1) Bar with circular cross sec-

tion, subjected to torsion and tension (solved by Symonds too); (2) unequally heated rotating disk; (3) three-dimensional body with nonstationary temperature distribution. Method employed is based on the choice of a residual (shakedown) stress distribution; its multiplier is determined from the condition that shakedown load should reach greatest value. O. Halasz, Hungary

102. Monastyrskii, O. A., On plastic flow in a thin layer (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 107–110, June 1958.

Author investigates the plane strain state of a thin layer in the neighborhood of a curve along which maximum shear stress is acting and gives approximate solutions of the stress and displacement fields. As example a plastic body pressed between two rough plates is investigated. O. Halasz, Hungary

103. Ivlev, D. D., Theory of perfectly hardening media, *Soviet Phys.-Doklady* **5,** 1, 66–70, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **130,** 4, 742–745, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

Some of the problems in the theory of perfectly hardening media are considered. Medium considered is assumed to be: (1) homogeneous; (2) isotropic; (3) incompressible. Furthermore, author assumes that: (4) the behavior of the material is independent of any change of sign in the stresses; and (5) the medium is perfectly hardening. From author's summary

104. Koistinen, D. P., and Marburger, R. E., A study of residual stresses in hardened steel induced by phase transformations, *GM Engng. J.* **7,** 3, 13–17, July/Aug./Sept. 1960.

Recent advancements in the application of X-ray diffraction techniques to the measurement of residual stresses in hardened steel have made it possible to make studies on the effects of mechanical and thermal treatments in steel which, heretofore, have been impractical. Such studies are being conducted at the Company of the authors. One study has resulted in new knowledge on the origin and distribution of residual macrostresses beneath mechanically finished surfaces and those found in exceedingly shallow surface layers on carburized and through-hardened steels. X-ray diffraction methods also are being applied to gain more knowledge on the origin of microstresses in hardened steel and their effect on its mechanical behavior. Progress has been made on obtaining quantitive information on the distribution of microstresses and the changes which accompany tempering.

From authors' summary

105. Klinov, I. G., An experimental investigation of the influence of linear mechanical hardening of steel of low carbon content on its plasticity when subsequently subjected to deformation in the reverse direction (in Russian), *Sb. Nauchn. Trudi Leningrad Inzh.-Stroit. In-ta* no. 26, 224–238, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3294.

The subject given in the title is explained and covers: (1) the influence of hardening of tension on subsequent compression; (2) the influence of hardening by compression on subsequent tension. In the first case plasticity is also studied; this makes its appearance after "twice-repeated" hardening—by tension-compression-tension. The tests were carried out on cylindrical test samples made of steel brand 3; fracture and tensioning was done on a 50-ton universal machine, compression on a 150-ton press, using special centering devices. The following conclusions were arrived at: 1. Softening of the steel occurs when the signs of the prehardening and subsequent loading in accordance with the conditions of the linear stressed state do not coincide. 2. In the case of "twice-repeated" preliminary plastic deformation and subsequent work (of differing signs) in the direction of the original cold hardening (tension – compression – tension) the following occurrences were noticed: (1) if the actual stresses s of the repeated hardening are less than the stresses s' of the initial plastic deformation then the dominant influence on the character of the diagram $s - e$ at working load will possess a higher degree of cold hardening; (2) should $s'' \geqslant s'$ then the character of the diagram $s - e$ will be the same as in the case of single preliminary hardening followed by loading of the opposite sign. V. A. Sveshnikova

Courtesy Referativnyi Zhurnal, USSR

106. Strunin, B. M., The inhomogeneity of plastic deformation in extension, *Soviet Phys.-Doklady* **5,** 1, 151-154, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130,** 2, 310-313, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

107. Ivlev, D. D., The equations of linearized space problems in the theory of ideal plasticity, *Soviet Phys.-Doklady* **5,** 1, 168-171, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130,** 6, 1232–1235, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

108. Komkov, W., On theoretical considerations of plastic-flow criteria, *J. Aero/Space Sci.* **27,** 6, 477–478 (Readers' Forum), June 1960.

Rods, Beams and Strings

(See also Revs. 4, 70, 100, 136, 163, 174, 176, 191, 196, 242, 245, 247, 253, 262, 502)

109. Gregory, M., A non-linear bending effect when certain unsymmetrical sections are subjected to a pure torque, *Austral. J. Appl. Sci.* **11,** 1, 33–48, Mar. 1960.

Using elastic theory only author finds that pure torque of rod of unsymmetrical section results in bending in addition to the expected twist. This effect is verified by experiments on brass angle section and good agreement is obtained.

W. M. Shepherd, England

110. Mathey, R. G., and Watstein, D., Effect of tensile properties of reinforcement on the flexural characteristics of beams, *J. Amer. Concr. Inst.* **31,** 12, 1253–1273, June 1960.

The effect of magnitude of steel stresses and the nature of the stress-strain characteristics on the center deflection, strain in the concrete, widths and spacing of cracks in the region of constant bending moment, load-carrying capacity, and the manner of failure were investigated in a series of flexural beam tests. This series consisted of 12 rectangular concrete beams reinforced with six different types of steel bars with yield strengths ranging from 43,5000 to 104,400 psi. The ratio of reinforcement was proportioned inversely to the yield strength, thus providing equal resistance to yielding under tensile forces.

Failure occurred in all the beams at approximately the same load. Test results were compared with values computed with the "straight line" and "ultimate strength" theories. The relationship between the computed steel stresses and the center deflections, width and spacing of cracks, and strain in the steel and concrete was determined for the six types of steel bars.

From authors' summary

111. Liu, C. Y., Neutral axes of curved beams, *Mach. Design* **32,** 18, 145–147, Sept. 1960.

A graphical method for speeding the design of curved beams having circular segment cross sections.

From author's summary

112. Kirz, L. B., and Lee, S.-L., Ultimate strength of over-reinforced beams, *Proc. Amer. Soc. Civ. Engr.* **86,** EM 3 (*J. Engng. Mech. Div.*), 95–105, June 1960.

The flexural strength of rectangular reinforced-concrete beams controlled by compression is investigated analytically, using stress distribution derived from experimental stress-strain curves. Empirical expression for the ultimate bending moment is presented and the calculated moments of fifty-nine test beams that failed in compression are compared with the ultimate test moments.

From authors' summary

113. Arutyunyan, N. Kh., and Chobanyan, K. S., Deflection of prismatic beams composed of various materials, account being taken of creep (in Russian), *Izv. ArmSSR. Ser. Fiz.-Matem. Nauk* **10,** 5, 59–72, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3055.

The problem is investigated regarding the deflection of a composite cantilever beam by a transverse force, with consideration for the creep of the materials from which the beam is made. It is assumed that the transverse section of the beam possesses one axis of symmetry and that the transverse force is acting in the plane of symmetry. The law of creep is applied in the form proposed by N. Kh. Arutyunyan ["Some questions relating to creep," Gostekhizdat, 1952]. The problem leads to the search for the stress functions. The theorem on the circulation of the tangential stresses of the deflection is generalized. The problem is also investigated on the deflection of a beam fitted with a reinforcing covering in its approximate setting. As an example the examination of the deflection of a composite beam of rectangular section is furnished.

Khuan Ke-chzhi

Courtesy Referativnyi Zhurnal, USSR

114. Mikinin, L. V., Displacements during deflection in an orthotropic cantilever beam under the action of a load distributed in accordance with the linear principle (in Russian), *Nauchno-Tekhn. Inform. Byul. Leningrad Politekhn. In-ta* no. 1/2, 172–176, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3132.

Using known formulas for the stresses, determinations are made of the displacements in a cantilever orthotropic beam with a transverse section in the form of a narrow rectangle, which is subjected to a load distributed linearly. The case is investigated in which the axes do not coincide with the principal directions of the elastic symmetry of the material of the beam.

E. F. Burmistrov

Courtesy Referativnyi Zhurnal, USSR

115. Kachurin, V. K., The "danger spots" in deflections of double-I beams (in Russian), *Sb. Leningrad In-ta Inzh. Zh.-d. Transp.* no. 156, 3–25, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3143.

A more precise method is proposed for the computations of the reduced pressures in the upper portion of the lower flange of the double-I beam. For the general case the solution is effected by the methods of the resistance of materials. It is assumed that the transverse force $Q = Q_a + Q_c$, where Q_a is the transverse force which produces the distortion of the section, and Q_c is the constricted transverse force which does not produce deformation of the section. The solution of Q_c is sought in the form of

$$Q_c = c_1 \operatorname{sh} \beta x + c_2 \operatorname{ch} \beta x \qquad \beta = \sqrt{\frac{Gl}{ES_T}}$$

where c_1 and c_2 are determined from the conditions governing the fastening, while S_T is the moment of distribution between Q_c and Q_a. It was shown, on the most unsatisfactory examples of combinations of forms of loading and forms of beam sections, that the magnitude of the brought-in stresses calculated by the proposed method does not exceed that permitted in practice. It is noted that the graphs of the tangential stresses drawn in accordance with the proposed improved method show analogy to the graphs drawn according to the methods of the theory of elasticity.

S. V. Zhuravlev

Courtesy Referativnyi Zhurnal, USSR

116. Barbarito, B., Simplified calculation of beams on elastic foundation (in Italian), *Ingegnere* **33,** 10, 897–905, Oct. 1959.

The paper presents a method of solving the beam equation and discusses the use of influence factors. A number of tables and diagrams are presented, but nothing especially novel.

W. H. Hoppmann II, USA

117. Budzianowski, Z., Some aspects of the theory of short rods on elastic foundation (in Polish), *Inżyn. Budown.* **16,** 8, 309–317, Aug. 1959.

A statically loaded bar of finite length and with free ends rests on an elastic foundation of Winklerian type. Making use of the Mohr integral, author derives the equation of the deformed line. It is composed of an algebraical part and of rapidly convergent trigonometrical series.

Z. Kaczkowski, Poland

118. Pan, C.-C., Analysis of stepped beams on spring foundation, *Scientia Sinica* **7,** 8, 856–870, Aug. 1958.

Author deals with a stepped beam on an elastic foundation deriving for each member beam (EJ = constant) the expressions (F) of end moments and shear forces. The expressions correspond to the slope-deflection equations of the usual rigid frame analysis. In these equations the fixed-end moments and the shear forces are "load constants" of the beam. Besides, there are "shape constants" in the equations corresponding, among others, to the flexural stiffness, thrust stiffness and carry-over factor in the usual moment-distribution method. Expressions of load constants, deflections and rotations are derived for different loading conditions. The deflections and rotations of the stepped beam in the stepped sections are calculated by solving a set of simultaneous equations, which are established with the aid of equilibrium conditions. The method of calculation is, in short, quite similar to the known slope-deflection method of rigid frames. Finally, the end moments and shear forces are calculated from the afore-mentioned expressions (F).

E. Niskanen, Finland

119. Varga, L., The foundation coefficient and design methods based on its use (in Hungarian), *Mélyépítéstudományi Szemle* **9,** 9, 401–412, 1959.

Author publishes the basic principles of various calculation methods for beams on elastic foundations, further he analyzes the approximations connected with the coefficient. Advantages resulting from the flexibility of foundations may be successfully utilized in the designing of the foundation.

From author's summary

120. Thoms, R. L., Experimental study of beams on elastic foundations, *Proc. Amer. Soc. Civ. Engrs.* **86,** EM 3 (*J. Engng. Mech. Div.*), 107–118, June 1960.

The design and use of a structural model for the solution of shear and moment in a beam on an elastic foundation is presented. Through use of the model, a typical problem of a laterally loaded pile foundation is solved as an example.

From author's summary

121. Kaminskaya, V. V., and Reshetov, D. N., Approximate analysis of the torsion of a box beam with a hole in the wall (in Russian), *Vestnik Mash.* **40,** 2, 3–7, Feb. 1960.

The title problem is treated by considering separately the equilibrium of sections (a) containing the hole and (b) of those not containing it. For sections (a) uniform distribution of shear stresses is related to the applied moment through an unknown parameter.

For sections (b), along the height, linear and parabolic variations are assumed for normal and tangential stresses. The unknown parameter is determined by minimizing the energy of deformation. Possible extension by taking larger number of such sections is noted. Noting the difficulty in obtaining an exact solution, the results, as shown, compare very well with the experimental results.

G. A. Nariboli, India

122. Babloyan, A. A., Torsion of prismatic beams of box shape in transverse section, with a fissure (in Russian), *Izv. Akad. Nauk ArmSSR. Fiz.-Matem. Nauk* **11**, 2, 89–97, 1958; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6634.

A solution was obtained by means of the method of supplementary functions [see N. Kh. Arutyunyan, *Prikl. Mat. Mekh.* **13**, 5, 551–556, 1949]; it was expressed in series by trigonometrical functions, the function of stresses having different analytical expressions for five subregions. The coefficients in the series are determined by completely regular infinite systems of linear equations. Results are given for the calculations for rigidity for different values for the section's parameters.

V. K. Prokopov

Courtesy Referativnyi Zhurnal, USSR

123. Ang, A. H.-S., Analysis of frames with non-linear behavior, *Proc. Amer. Soc. Civ. Engrs,* **86,** EM 3 (*J. Engng. Mech. Div.*), 1–23, June 1960.

Author presents an iterative procedure for solving the equations of joint moment equilibrium and joint rotational continuity for rigid and nonrigid frames with joint loadings only and with members stressed in the plastic, work-hardening range.

A single moment-curvature curve is derived which holds with sufficient accuracy for all wide-flange sections of A-7 steel.

Two simplified illustrative problems are solved. Reviewer questions whether, for more complicated frames, convergence difficulties may not arise since, in the iterative technique used, different terms may be changed in each computational cycle and one has no way of knowing whether a particular change will actually be in the required direction.

S. F. Borg, USA

Plates, Shells and Membranes

(See also Revs. 29, 77, 80, 82, 89, 164, 168, 169, 170, 173, 178, 180, 181, 183, 224, 226, 244, 247, 253, 260, 265, 288)

124. Corneliussen, A. H., and Shield, R. T., Finite deformation of elastic membranes with application to the stability of an inflated and extended tube, Brown Univ., Div. Appl. Math., TR 6 (Contract DA-19-020-ORD-4725), 67 pp., June 1960.

A theory is formulated for the finite deformation of a thin membrane composed of homogeneous elastic material which is isotropic in its undeformed state. The theory is then extended to the case of a small deformation superposed on a known finite deformation of the membrane. As an example, small deformations of a circular cylindrical tube which has been subjected to a finite homogeneous extension and inflation are considered and the equations governing these small deformations are obtained for an incompressible material. By means of a static analysis the stability of cylindrically symmetric modes for the inflated and extended cylinder with fixed ends is determined and the results are verified by a dynamic analysis. The stability is considered in detail for a Mooney material. Methods are developed to obtain the natural frequencies for axially symmetric free vibrations of the extended and inflated cylindrical membrane. Some of the lower natural frequencies are calculated for a Mooney material and the methods are compared.

From authors' summary B. E. Gatewood, USA

125. Odqvist, F. K. G., Non-steady membrane creep of circular plates (in English), *Arkiv för Fysik* **16,** 43, 527–531, 1960.

Author obtains expressions for radial and circumferential stresses and radial and vertical displacements in a clamped circular membrane subjected to vertical pressure. Elastic and plastic strains are neglected, and creep-rate components are taken proportional to the product of the appropriate stress deviators and some power of the second stress invariant. Radial and tangential stresses are expressed as power series in the radius, and solutions for the time-dependent coefficients appearing in the series are obtained by solving the ordinary differential equations which arise after substituting the series into the general equations. Solutions show that, as time increases, stresses decrease and vertical displacement increases, as expected intuitively.

W. E. Jahsman, USA

126. Javer, T., Remarks on the analysis of skew orthotropic plates (in German), *Bauingenieur* **34,** 12, 474–475, Dec. 1959.

These remarks refer to a paper of M. Nauroka and H. Yonezava [AMR **12**(1959), Rev. 1867] where the bending theory of orthotropic plates is applied to the analysis of a skew girder bridge with two opposite edges free and the other two edges simply supported, and for solving the differential equation, the method of finite differences is employed. Author shows that by means of a simple transformation, the problem of the skew plate can be reduced to that of the isotropic plate. A list is given of Slovakian papers which contain the calculation and the description of model testing carried out by author.

J. Barta, Hungary

127. Mansfield, E. H., The large-deflexion behaviour of a thin strip of lenticular section, *Quart. J. Mech. Appl. Math.* **12,** 4, 421–430, Nov. 1959.

Author solves large-deflection problem for special case of thin strip having lenticular parabolic cross section and subjected to combined torque and bending moment, the buckling regime being also considered. It is found that for shape of cross section assumed, chordwise curvature of strip is constant, resulting in simplification of analysis. Results are applied to following special cases: pure moment; pure torque; moment and torque increasing in fixed ratio; flexural snap-through buckling of torsionally buckled strip.

A. M. Wahl, USA

128. Cox, H. L., and Dawson, D., The effect of initial lateral tension or slackness on the deflection of long, thin plates under normal pressure, *J. Roy. Aero. Soc.* **63,** 587, 672–674 (Tech. Notes), Nov. 1959.

Karman's equations for large deflections of thin plates under normal pressure are solved under the assumptions that the deflections vary across the width only and that the lateral tension is constant. The effects of initial tension or slackness in the plate and of deformation of the supports at the long edges are taken into account.

The calculations are simplified by adaptation to the Roy. Aero. Soc. Sheet Data.

The experiment shows quite good agreement with theory.

A. Kornecki, Israel

129. Modor, Z., Analysis of plates of polygonal form (in German), *Bauingenieur* **34,** 11, 427–437, Nov. 1959.

Infinitesimal deformation of thin, elastic, homogeneous and isotropic triangular plates due to linearly distributed transverse load. Using the well-known differential method of Marcus, author derives equations necessary for calculation of reactions of bending moments at supported edges and of maximal bending moments between supports. Author points out that this method may also be applied to built-in trapezium plates with equal sides and to any arbitrary triangular plates with two edges built-in and the third edge freely supported, etc.

This problem is solved for uniformly loaded built-in triangular plate whose angles are 40°, 60°, and 80°, respectively. Corresponding numerical values are also tabulated in diagram for built-in isosceles triangular plates with varying angles between the two equal sides. The load is uniformly or linearly distributed.

S. T. A. Odman, Sweden

130. Naruoka, M., Investigation of an oblique plate with the aid of a digital computer (in German), *Bauingenieur* **34**, 10, 401–406, Oct. 1959.

The bending of a simply supported oblique plate is investigated by means of the finite-difference method. For solving the system of finite-difference equations FACOM-128 (Fuji Relay Automatic Computer) is used.

The main part of the paper presents the tables of influence-coefficients of the deflection, the bending and twisting moments of plates, with 30°, 45° and 60° skew.

V. Kovarik, Czechoslovakia

131. Vybornov, V. G., Large deflections in a freely supported rectangular cylindrical panel during evenly applied tension-compression and normal external pressure (in Russian), *Ucb. Zap. Kazansk. In-ta* **117**, 9, 71–74, 1957; *Ref. Zb. Mekb.* no. 3, 1959, Rev. 2903.

The problem given in the title is solved by Castigliano's method, the method of Bubnov-Galerkin being applied to the equation of joint action while the equation of equilibrium is integrated in series. It is shown that the use of Castigliano's method results in the same correlations being obtained as when the mixed method is used for the solution of the problem in question; in the latter, expressions are assigned for the functions of stresses and of deflection while the initial equations are integrated by the Bubnov-Galerkin method. Numerical examples are given.

M. S. Kornishin

Courtesy Referativnyi Zhurnal, USSR

132. Shengeliya, G., Calculations for thin plates of variable rigidity (in Russian), *Trudi Gruz. Politekbn. In-ta* no. 9 (57), 193–198, 1957; *Ref. Zb. Mekb.* no. 3, 1959, Rev. 2929.

The transverse deflection of a rectangular plate of variable rigidity is investigated. A differential equation of an elliptical type

$$\Delta\Delta u = \lambda f\left(x,\ y,\ u,\ \frac{\partial u}{\partial x},\ \frac{\partial u}{\partial y},\ \frac{\partial^2 u}{\partial x^2},\ \frac{\partial^2 u}{\partial x \partial y},\ \frac{\partial^2 u}{\partial y^2}\right)$$

with boundary conditions $u = 0$, $\partial u/\partial n = 0$ leads to the equivalent integrodifferential equation, the solution of which is obtained by means of the method of successive approximations.

V. F. Karavanov

Courtesy Referativnyi Zhurnal, USSR

133. Perlin, P. I., Analysis of contact stresses in bearing plates (in Russian), *Vestnik Masb.* **38**, 3, 17–20, Mar. 1958.

Author proposes to find the contact stresses for a system of pyramidically arranged layer of plates. It is argued that for plates of dimensions used in practice, these can be approximated successively from the solution for a semi-infinite region. Galin's potential-type representation is used. The integral is evaluated approximately. Sketches are given to show the results.

G. A. Nariboli, India

134. Kurdin, N. S., Bending of rectangular plates subject to the action of localized static loads and with various boundary conditions (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **26**, 199–204, 1958.

Ritz's method is used for solving the problem of bending of rectangular plates with constant thickness for various edge conditions (two opposite edges are free and the other two edges constrained, or all four edges are constrained). The load is distributed uniformly on the surface bounded by the rectangle. The deflection surface is selected in the form of a double series the members of which are constituted by the derivatives of the so-called beam functions. The solution of a square plate is given as an example.

J. Valenta, Czechoslovakia

135. Legendre, R., Stress distribution in a disk (in French), *C. R. Acad. Sci., Paris* **249**, 10, 945–946, Sept. 1959.

136. Dutt, S. B., Torsion of a large thick plate with rigidity varying linearly with depth and rigidly fixed at one face (in English), *ZAMM* **39**, 7/8, 290–295, July/Aug. 1959.

Paper deals with the torsional problem of a thick plate or disk whose shearing rigidity varies linearly with depth. The shearing tractions applied at the bounding planes vary with radial distance to satisfy boundary compatibility and give rise to twisting couples. A solution is presented first for the case of a rigidly fixed bottom face, and then extended to the case where both faces are acted upon by radially variable shearing forces.

N. A. Weil, USA

137. Cheng, S., Torsion of sandwich panels of trapezoidal, triangular, and rectangular cross sections, For. Prod. Lab., U. S. Dept. Agric. Rep. 1874, 20 pp., June 1960.

Book—138. Casacci, S., and Bosc, J., Calculation of bending of conical shells of constant thickness under axially symmetrical loads—Tables of influence coefficients, comparison with cylindrical shells, with circular plates and with conical strips [Calcul à la flexion des coques coniques d'épaisseur constante soumises à des charges axisymetriques—Tables des coefficients d'influence comparaison avec les coques cylindriques, les plaques circulaires et les anneaux coniques], Paris, Dunod, 1959, xiv + 161 pp. 1800 F. (Paperbound)

Chapter I gives the derivation and transformation of the basic differential equation derived from the stress-strain relations. In the next chapter a general study is made of the bending of truncated cones, especially with respect to boundary conditions of loads and displacements. The case of long cones is solved first with the aid of Bessel or Kelvin functions and then approximately with an asymptotic expansion, in Chapter III, and the domain of validity is examined in Chapter IV. Authors show in Chapter V that the general equations reduce to cylindrical shells, circular plates, and conical strips in the limiting cases. As an example a conical shell with cylindrical ends is solved in Chapter VI. Appendices give more detailed account of the derivations and also the solution in tabular form.

N. C. Costakos, USA

139. Kuhelj, A., The integration of the differential equations for thin elastic circular cylindrical shells on many supports (in German), *ZAMM* **39**, 9/11, 413–414, Sept/Nov. 1959.

In a brief note the author indicates that problems involving a segment of a cylindrical shell can be solved by a method similar to that of Mr. Levy for rectangular plates. No examples are given.

Although this method of solution presents no conceptual difficulties, it will lead to very involved computations [Timoshenko and Woinowsky-Krieger, "Theory of plates and shells," 2nd. ed., McGraw-Hill, 1959].

E. H. Dill, USA

140. Biderman, V. L., Calculation for the form of profile and stresses in the parts of a pneumatic tire subjected to internal pressure (in Russian), *Trudi N.-i. In-ta Shin. Prom-sti* no. 3, 16–51, 1957; *Ref. Zb. Mekb.* no. 3, 1959, Rev. 3282.

By looking at the outer cover as a thin shell loaded by internal pressure and by taking the length of the cord's filaments as independent of the pressure in his first approximation the author de-

termines the conditions for geometrical equilibrium of the configuration of the tire. Nomographs are drawn of the equations obtained for the most frequently occurring types of covers met in practice. With their aid it is possible to determine the profile of the tire cover and the dimensions of the tire rim which are required to fit the tire to a given outer diameter and with a profile of a given width; it is possible to produce a profile and to determine the outer diameter of the inflated tire according to the given dimensions of the rim and the width of the profile of the tire cover, and also to determine the configuration of the inflated tire in accordance with the given dimensions of the vulcanizing mould.

S. V. Zhuravlev

Courtesy Referativnyi Zhurnal, USSR

141. Prokopov, V. K., The framework method of calculation for a cylindrical shell with reinforcing ribs (in Russian), *Naucbno-tekbn. Inform. Byul. Leningrad Politekbn. In-ta* no. 12, 13–15, 1957; *Ref. Zh. Mekb.* no. 3, 1959, Rev. 2911.

A method is proposed for calculating the strength of cylindrical vessels, reinforced with symmetrically placed longitudinal ribs of sufficiently large stiffness, with the adoption of the following simplifying assumptions: (1) the tension on the ribs can be disregarded and the deformation of the shell consequently exercises no influence on the position of the neutral axis of the rib; (2) because of the restraining effect of the ribs the principal influence is exercised by the radial transpositions of the shell and the rest of the transpositions can be disregarded. The gist of the method lies in the evaluation in the first approximation of the work of construction, leaving only the rod system consisting of stiff ribs and flanges (frame-work). The author proceeds by making use of the theory of the deflection of girders, by transferring to the ribs a corresponding part of the load bearing on the shell and taking into account the supplementary load, the appearance of which is a condition of the deformation of the shell. R. G. Surkin

Courtesy Referativnyi Zhurnal, USSR

142. Amirikian, A., Multipurpose building of precast thin-shell panels, *J. Amer. Concr. Inst.* **31,** 12, 1243–1252, June 1960.

An assembly of simple precast panels, connected together by bolts and welded inserts, provides the structural framing of a single-story gable-proof building, suitable for many uses. The panels are ribbed, consisting of a thin slab and peripheral stiffening members. Arranged for 4-ft modular framing, two pairs of panels—one pair placed in the roof and the other in the sidewalls—compose a building segment 4 ft wide.

Framing arrangement, design, assembly, and jointing are discussed. Information is also given on strength tests and service behavior of an experimental building built of these panels.

From author's summary

143. Sawczuk, A., and Hodge, P. G., Jr., Comparison of yield conditions for circular cylindrical shells, *J. Franklin Inst.* **269,** 5, 362–374, May 1960.

The yield condition for a rigid-plastic circular cylindrical shell subjected to axially symmetric loading is given in terms of the circumferential hoop stress n and the axial bending moment m. There is in an n, m plane a closed (so-called interaction) curve. A state of stress n, m within this curve leaves the cylinder undeformed; a state of stress on this curve makes plastic deformation possible, states of stress outside the curve are not possible. The curves, derived from Mises and Tresca yield conditions, are quoted from previous [AMR **8**(1955), Rev. 1665] and to-be-published work of one of the authors. Reviewer believes that there could be some artificial element in the derivation since a bar or plate of nonhardening plastic material has another moment-rotation relation than the present shell has, since there is no gradual transition from a fully elastic to a fully plastic state.

For a state of stress on the interaction curve the displacements are derived with the aid of a generalization of the plastic potential law.

Shells of uniform thickness and sandwich shells are investigated. The load is a single ring load. Stress distributions and collapse loads (based on Mises and Tresca yield conditions) are computed and compared. J. P. Benthem, Holland

144. Greenspon, J. E., Vibrations of a thick-walled cylindrical shell—comparison of the exact theory with approximate theories, *J. Acoust. Soc. Amer.* **32,** 571–578, May 1960.

The results for vibrations of an elastic cylinder as predicted by a number of the approximate shell theories are compared with the results of the exact theory. It is found that the membrane theory of shells is accurate for predicting frequencies and displacement ratios of cylinders with appreciable thickness. Furthermore, the theories which include bending effects as well as membrane effects are good at even the shorter wavelengths; and the theories which include rotatory inertia and shear are accurate over most of the wavelength spectrum of the lowest branch of rather thick shells. However for the very thick shell (with a ratio of inside radius to outside radius less than 0.5), only the exact theory shows the full characteristics of the displacement distribution.

From author's summary by E. G. Fischer, USA

145. Tooth, A. S., Kenedi, R. M., and Hossack, J. D. W., The use of semi-graphical methods in the stress and deformation analysis of shell forms, *Struct. Engr.* **38,** 4, 129–137, Apr. 1960.

General problem considered is the practical determination of stresses and deflection at points in the neighborhood of distributed loads applied to shallow shells. The specific problem treated is that of a shallow spherical cap subjected to radial load uniformly distributed over a circle of latitude. Stresses and deflections are calculated by semigraphical superposition of the stresses and deflections due to concentrated loads acting along the loaded latitude. The stresses and deflections due to a concentrated load (actually due to load on a small, but finite area) are taken from E. Reissner's solution for shallow spherical shells. Experiments were performed to,check the applicability of Reissner's basic solution and the accuracy of the graphical method used. Agreement between experiment and theory was quite good in the cases reported. B. Paul, USA

146. Csonka, P., Formulas for calculation of stresses in shell domes (in German), *Bautechnik* **37,** 2, 59–62, Feb. 1960.

The title of the paper is rather more embracing than its contents as it is only concerned with the membrane state in dome structures. From the well-known equilibrium conditions of projected membrane forces the author concludes that at certain points of the shell (such as e.g. the corners or some points on the axes of symmetry) it is possible to derive membrane forces explicitly without reference to the complete solution for which other approximate methods exist. Such "control points" doubtless are a valuable checking method, though by themselves are insufficient for complete design.

O. C. Zienkiewicz, USA

147. Herzog, M., The fundamental equations of the surface of thin elastic shells with variable wall thickness and finite deformations subject to arbitrary loading and temperature variation (in German), *Bautechnik* **37,** 1, 27–29, Jan. 1960.

Author extends basic equations by Marguerre (1938) of shells with constant thickness to general problem of shells with variable thickness. G. G. Meyerhof, Canada

148. Mihailescu, M., and Mihailescu, Y., Application of the relaxation method to the computation of shells (in English), *Rev. Mécan. Appl.* **5,** 1, 103–114, 1960.

The possibilities are discussed of expressing, with the aid of finite differences, the equilibrium equations of thin shells in the membrane and bending theories. The form of the finite difference equations for various types of surfaces is shown.

From authors' summary

149. Palmer, P. J., A method of analysis for axially symmetrical shells with constant meridional curvature, *Quart. J. Mech. Appl. Math.* **12,** 4, 431–442, Nov. 1959.

Author solves differential equations for shell of constant thickness and having axial symmetry and constant meridional curvature, with particular reference to case where shell is corrugated pipe. Simplification is effected by assuming that meridional radius of corrugations is small compared to mean radius of pipe, solution being expressed in series form for case where included semi-angle of corrugations is less than about $\pi/3$. Calculated results show reasonable agreement with test data, for case where pipe is subject to internal pressure.

A. M. Wahl, USA

150. Cicala, P., Elastic theory of thin shells, Parts 1, 2, 3, and 4 (in Italian), *G. Gen. Civ.* **97,** 4, 238–245, Apr. 1959; **97,** 4, 245–256, Apr. 1959; **97,** 6, 429–449, June 1959; **97,** 9, 714–723, Sept. 1959.

Author constructs a two-dimensional linear theory of thin elastic shells by starting with the three-dimensional equations of linear elasticity for homogeneous isotropic materials referred to the oblique coordinate system generated by the normal to the shell midsurface and an arbitrary curvilinear coordinate net on the midsurface. The reduction from three to two dimensions is accomplished by the expansion of displacements and stresses in infinite series of Legendre polynomials in the thickness coordinate. The orthogonality of these polynomials facilitates the retention of all terms in the expansions, leading to a system of infinitely many differential equations in infinitely many unknowns. Approximate systems of shell equations are then obtained by truncation. This program is carried out for general shells in part IV, having been carried through in greater detail for shells of revolution in part II. In part III author studies special solutions of truncated systems for shells of revolution corresponding to membrane and inextensional stress states, and to edge effects. Part I is an introduction. Many references are listed, but comparisons of author's various truncated systems for general shells with those of other authors are not given.

J. K. Knowles, USA

151. Tao, L. N., On toroidal shells, *J. Math. Phys.* **38,** 2, 130–134, July 1959.

The elastic displacement equation of toroidal shells is integrated in closed form and expressed in terms of the Heun function [A. Erdelyi, ed., "Higher transcendental functions," Vol. III]. Although this solution is represented by a power series, as were those presented by previous authors, it is applicable to the entire shell and indicates that the fundamental solutions are even and odd functions of the opening angle.

M. G. Salvadori, USA

152. Reissner, E., On influence coefficients and nonlinearity for thin shells of revolution, *ASME Trans.* **81** E (*J. Appl. Mech.*), 1, 69–72, Mar. 1959.

Rotationally symmetric deformations of thin elastic shells of revolution subjected to edge forces and moments are investigated according to author's nonlinear theory [AMR **4**(1951), Rev. 1985]. In accordance with known results from linear theory for thin nonshallow shells, the equations are simplified by considering that the deformations are contained within a narrow edge zone. Nonlinear system is solved by expansion in powers of displacement parameters. An interesting result is obtained: due to second-degree terms vanishing only for shells with axially directed edge tangents, forces and moments tending to flatten (deepen) the shell produce larger (smaller) deflections than predicted by linear theory.

P. Cicala, Italy

153. Lawruk, B., A hinged thin shallow spherical shell rectangular in the horizontal projection (in English), *Bull. Acad. Polonaise Sci. (IV)* **7,** 7/8, 413–418, 1959.

The problem of solving the usual, or Reissner, partial differential equations over a rectangular region with an arbitrary distributed normal load is reduced to the problem of solving a lower-order normalized system of equations. No applications are given but a more extensive paper is to appear later.

R. A. Clark, USA

154. Matildi, P., Equations of elastic equilibrium of thin shells of any shape (in Italian), Atti Ist. Sci. Costr., Univ. Pisa, Pub. 63, 20 pp., 1959.

A clear and concise derivation of linear equations of thin shells corresponding to equations of Love's first approximation but free of the known inconsistency of Love's stress-strain relations. A full discussion of the problem is available in fundamental works such as Gol'denveizer's [see AMR **10**(1957), Rev. 2471].

S. J. Medwadowski, USA

155. Mitrofanova, A. V., Design of shells having initial irregularities from a given form (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **26,** 39–48, 1958.

Author establishes a theory for the design of elastic shells with initial irregularities by applying first the general equation of the nonlinear theory of elasticity. The equation is written in curvilinear coordinates and simplified in accordance with the hypothesis of straight normals. The equation of the middle surface of the shell (with initial irregularities) is obtained by giving the points on the regular shell small initial displacements u_0, v_0, and w_0 but not stressing the shell. In the next step author gives the same points an additional displacement v, v and w which produces the irregularities. This method permits the use of curvilinear coordinates for the calculation of the ideal shell (without irregularities). The general equation is then simplified by disregarding terms of higher order.

M. Maletz, USA

156. Dressler, R. F., Bending and stretching corrugated diaphragms, *ASME Trans.* **81** D (*J. Basic Engng.*), 4, 651–659, Dec. 1959.

Solutions of the exact linear equations for a rotationally symmetric elastic shell with a pattern containing several concentric ridges or corrugations, which is deflected to an equilibrium position under an applied air pressure, are presented. The results were obtained by numerical integration using an electronic digital computer and give stresses and deflections for three thicknesses varying over a 9 to 1 range. The method has previously been applied by the author in *ASME Trans.* **79,** pp. 65–82, 1957 [AMR **1** (1958), Rev. 445], and has been repeated here for purpose of generalizing the effects of variations in thickness.

J. A. Cheney, USA

157. Jaworski, A., A shell of revolution with a central top cut-out reinforced by a ring rigid to bending and torsion, loaded by a concentrated force arbitrarily directed (in Polish), *Arch. Budown Maszyn* **6,** 2, 279–306, 1959.

Author presents an approximate solution. In the shell membrane stresses only are considered. Thus continuity of strains and displacements between ring and shell cannot be obtained. Author considers sine and cosine distributions of zero-resultant stresses acting between ring and shell. The amplitude of successive stress distributions is obtained considering minimum of strain energy. The method is outlined for second-degree surfaces of revolution

with positive Gaussian curvature. Detailed relations and a numerical example are given for spherical shells. Since bending moments in shell are neglected, the results may differ considerably from the real stresses.

P. Wilde, Poland

158. Malkina, R. L., Analysis of noncircular closed cylindrical shells subject to arbitrary boundary conditions (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **26,** 25–38, 1958.

In his treatise on the "Theory of thin elastic shells," Gol'denveiser gives the basic approximate methods of analysis of cylindrical shells of arbitrary cross section and points out that not one of these methods is applicable to the solution of cylindrical shells when edge effects are taken into consideration.

The solution of cylindrical shells of any cross section and any length acted upon by uniform internal pressure was given by Novozhilov (see his monograph "The theory of thin shells," 1951). Author presented a modification of Novozhilov's method in 1954 before the Russian Academy of Sciences, and although the problem was solved for any boundary condition, the formulas obtained then were too cumbersome for practical purposes. In the present article author presents a continuation of his work of 1954; the analysis is completely simplified and formulas obtained are amenable to practical solutions.

From author's summary by M. Maletz, USA

159. Galimov, K. Z., Variational equations in the nonlinear theory of slanting shells (in Russian), *Uch. Zap. Kazansk. In-ta* **117,** 9, 65–70, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2900.

Two variational equations in the nonlinear theory of slanting elastic shells are considered, the boundary conditions set being of a sufficiently general nature. In a special case where the edges of the shell are rigidly clamped or the edges are free from external loads tangentially to the central surface, the contour integrals in the proposed variational equations disappear. The equations would then take the form

$$\iint (D\nabla^4 w\,\delta w + B'\,\Psi\,\nabla^4\,\delta w\Psi - X^3\,\delta w)\,d\sigma = 0 \qquad [1]$$

$$\iint [B'\nabla^4\,\Psi\,\delta\Psi + \tfrac{1}{2}\,Dw\,\nabla^4\,\delta\varphi w + \tfrac{1}{2}(b_s^{\,s}\,a^{ij} - b^{ij})\kappa_{lj}\,\delta\Psi]\,d\sigma = 0 \qquad [2]$$

$$D = E\,b^3/12\,(1-\nu^2), \quad B' = 1/E\,b$$

E is the modulus of elasticity, ν the coefficient of transverse expansion, b the thickness of the shell, ∇^4 the biharmonic operator, w the deflection, Ψ the stress function, X^3 the normal component of the external loading, a_{ij} and b_{ij} the coefficients of the first and second forms of the middle surface, $\alpha_{ij} = \nabla_i \nabla_j w$. In [1] the variation $\nabla^4\,\delta_w\Psi$ should satisfy the correlation

$$B'\,\nabla^4\delta_w\Psi + c^{ij}c^{ks}(b_{ik} + \kappa_{ik})\,\delta\kappa_{sj} = 0$$

and in [2] the variation $\nabla^4\delta\varphi\,w$ – the relation

$$-D\,\nabla^4\delta\varphi w + (b_{ij} + \kappa_{ij})\,c^{i\alpha}c^{j\beta}\nabla\alpha\,\nabla\beta\,\delta\varphi = 0$$

With other types of boundary conditions operating in particular with a freely supported edge of the shell the left-hand-side portions of equations [1] and [2] will contain contour integrals as well.

N. A. Alumyae

Courtesy Referativnyi Zhurnal, USSR

160. Brush, D. O., Strain-energy expressions in nonlinear shell analyses, *J. Aero/Space Sci.* **27,** 6, 555–556 (Readers' Forum), July 1960.

161. Galimov, K. Z., The application of the variational principle of possible changes in the stressed state to the nonlinear theory of slanting shells (in Russian), *Izv. Vyssb. Uchebn. Zavedenii, Matematika* no. 1, 3–11, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2901.

Variational equations are put forward for the method of possible changes in the stressed state in the nonlinear theory for an elastic slanting shell, and some other variational equations resulting from conversions in the basic problem are pointed out. The physical correlations between the tensors of forces, the moments S^{ik}, M^{ik} and the tensors of deformation ε_{ik}, κ_{ik} are taken in the form of

$$\varepsilon_{ik} = \frac{\partial F}{\partial S^{ik}}, \quad \kappa_{ik} = -\frac{\partial F}{\partial M^{ik}}$$

where F is the deformation potential (supplementary work), expressed through the forces and moments. The principle of possible changes in the stressed state is represented by the variational equations

$$\iint_\sigma (v\,\delta X - \omega_\alpha\,\delta M^\alpha)\,d\sigma + \int_c (v_*\,\delta\Phi - \omega_{(n)}{}^*\,\delta G)\,ds +$$

$$+ w_*\,\delta H\,|_c = \delta \iint_\sigma \left(F + \tfrac{1}{2}\,S^{\alpha\beta}\,\omega_\alpha\,\omega_\beta\right) d\sigma \qquad [*]$$

where v is the displacement vector, X is the vector of external loading, ω_i are the angles of deflection, Φ is the vector of the contour force, w is the deflection, $\omega_{(n)} = dw/dn$ is the angle of deflection of the middle surface on the contour, M^i are the moments resulting from the external load, G is a normal, H is a torsional moment on the contour. Magnitudes assigned on the contour are marked with an asterisk. It is assumed that $\delta\,\Phi$ and δG change to zero value on portions of the contour where Φ and G are assigned; the comparable states of S^{ik}, M^{ik} should satisfy the equations of equilibrium, the angles of deflection ω_i in (*) however do not vary. Thus, in order to apply the variational equation [*] a previous requirement is to see that $w_i = \nabla_i w$ as an assigned value (and also to determine by these data $b_{ij}^* = b_{ij} + \kappa_{ij} = b_{ij} + \nabla_j\omega_i$); during the search for a solution for equation [*] these values adjust themselves, consequently it is apparently necessary to carry through solutions for equation [*] several times until the given tensor κ_{ij} and the solution of the variational problem $\kappa_{ij}^* = \partial F/\partial M^{ik}$ converge sufficiently well. This remark also applies to the use of variational equations of the Bubnov-Galerkin type for the approximate integration of the equations for joint deformation. A method is given for the formulation of boundary conditions in terms of forces and moments; three variants of boundary conditions are investigated in detail.

N. A. Alumyae

Courtesy Referativnyi Zhurnal, USSR

162. Levitskaya, N. D., Experimental verification of the strength of orthotropic cylindrical shells, reinforced by rings (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **26,** 101–112, 1958.

Simply supported cylindrical shells without and with a reinforcing ring in the midspan have been tested within elastic range under a concentrated force. Mild steel tubes had the thickness/radius ratio $b/R = 1/125$, and length/radius ratio $L/R = 1/8$. Strain-gage measurements show a good agreement with V. Z. Vlasov's approximate theory solution for medium length shells [V. Z. Vlasov, "Contact problems in the theory of shells," *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 319–837, 1949; AMR **3**(1950), Rev. 1666].

A. Sawczuk, Poland

Buckling

(See also Revs. 4, 90, 127, 239, 510)

163. Kavanagh, T. C., Effective length of framed columns, *Proc. Amer. Soc. Civ. Engrs* **86,** ST 2 (*J. Struct. Div.*), 1-21, Feb. 1960.

Paper deals with the design of compressed members in plane structures considering the end restraints of the bars (top chords,

diagonals, columns, etc.) and applying the effective length of buckling ($k \cdot l$) for the computation. Starting from the classic method of "bifurcation," author presents three typical cases of end restraints: (1) translational rigid; (2) translation and rotation possible; (3) little or no rotation possible. Special attention is given to the rotational restraining effect of compressed and tensile members in trusses and frameworks if plastic range is reached before buckling. Author points out that there is a considerable deterioration of restraint due to yielding transforming, for example, the fixed end of a column into a pinned end. Paper contains very valuable tables and nomograms which facilitate exact and approximate computation of buckling problems in trusses, and framed structures. Formula of Puwein for calculating buckling of multistorey frames is extended by charts of Julian and Lawrence. Arbitrary fixed values for the length coefficient k in the Standards lead generally to an overdesign but sometimes to an underdesign of the structure. Though it does not offer a new theoretical development, paper represents a very valuable contribution to a not only safe but economical dimensioning of frame-works and trusses.

H. Beer, Austria

164. Popov, S. M., Stability of bars and plates beyond the elastic limit (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **26,** 161–178, 1958.

Author derives design formulas for the determination of the critical load beyond the proportional limit for bars and plates for various end conditions. Two approximate methods for the establishment of critical parameters are used: (1) based on the resistance of the material to buckling—used in U.S.S.R., and (2) a method based on the hypothesis that during buckling plastic deformation takes place—used in the Western Countries. Author gives illustrative examples of how to use the methods and supplies graphs for computation of coefficients used in the respective formulas. Work is based on results obtained from the investigations of Ilyushin, Popov, Stowell, and Timoshenko. M. Maletz, USA

165. Gerard, G., Tangent-modulus column theory, *J. Aero/Space Sci.* **27,** 8, 627–628 (Readers' Forum), Aug. 1960.

166. Han, L. S., The buckling and deflection of isosceles-triangular plates, *ASME Trans.* **82** E (*J. Appl. Mecb.*), 1, 207–208 (Brief Notes), Mar. 1960.

Applying the Markus method in connection with minimizing operations according to Rayleigh-Ritz the author gives a solution for the buckling and bending problem of isosceles-triangular plates. The result includes the most known limit cases.

H. Neuber, Germany

167. Sensenig, C. B., The buckling of a thick circular plate using a non-linear theory, AFOSR TN 60-41 (New York Univ., Inst. Math. Sci. IMM-NYU 262), 8 pp., Dec. 1959.

Author assumes a thick circular plate, which is compressed along its curved lateral surface so that the generators of the cylinder remain straight lines and no shear stress is developed. The plane faces of the cylinder are free of stress. The problem is treated as three-dimensional and displacements and strains are not assumed to be small. A uniform plane strain satisfies all conditions. The question is, at what critical pressure is this simple state unstable. The material is described by the usual strain energy function of the linear theory. The report is restricted to buckled modes with symmetry about the axis of the cylinder, for which the critical buckling pressure is given. The result approaches the known solution of the linear theory for a thin plate with clamped edges. L. Foppl, Germany

168. Sunakawa, M., and Uemura, M., Symmetrical buckling of cylindrical shells under external pressure, Aero Res. Inst., Tokyo University Rep. 356, 107-117, May 1960.

Solution by Galerkin method is presented for large deflections of normally loaded cylindrical plate built-in along two straight edges of length l and simply supported along the curved edges that subtend an internal angle θ. Snap-through buckling is found. Method of solution can be applied to other boundary conditions.

G. W. Housner, USA

169. Weinitschke, H., On the stability problem for shallow spherical shells, *J. Math. Phys.* **38,** 4, 209-231, Jan. 1960.

Stability of shallow spherical shells under uniform normal pressure with axisymmetrical deformations is studied. The basic equations for small finite deformations of a spherical segment are given in two differential equations. Under given boundary conditions, the displacement of the shell varies with the normal pressure. The load at which an appropriate displacement-versus-pressure curve approaches infinite slope is the critical load. Series solutions of the differential equation with given boundary conditions are given. The validity of the series solutions is established by means of a detailed study of the convergence of the series. Certain techniques of practical significance for solving a rather general class of nonlinear boundary-value problems for ordinary differential equations are developed.

Stability curves for three cases of edge restraints are shown. The calculated buckling loads are compared with experimental observations. The discrepancy between the calculated and the observed values is briefly discussed.

T. H. Lin, USA

170. Abir, D., and Nardo, S. V., Thermal buckling of circular cylindrical shells under circumferential temperature gradients, *J. Aero/Space Sci.* **26,** 12, 803–808, Dec. 1959.

The thermal buckling of thin-walled circular cylindrical shells due to axial stresses caused by variation in temperature around the circumference is analyzed. This problem has applications in airplane and missile fuselage structures as well as in orbiting vehicle structures.

The analysis is performed using Donnell's equation. The variation of the thermal stress in the circumferential direction is represented by Fourier series; the stresses are assumed constant through the thickness and in the axial direction. The buckling deformations are also assumed to be represented by Fourier series. Neither postbuckling behavior nor the effects of initial imperfections are considered. The solution is shown to reduce to the classical solution for cylinders in pure compression when only this type of loading is used. The analysis also shows that buckling due to variable thermal stress conditions is close to the buckling stress for the pure compression condition. This last result requires that the variation of the thermal stress be small over one half buckle wavelength. D. W. Breuer, USA

171. Budiansky, B., and Weinitschke, H., On axisymmetrical buckling of clamped, shallow, spherical shells, *J. Aero/Space Sci.* **27,** 6, 545–546 (Readers Forum), June 1960.

172. Lianis, G., Torsional creep buckling of open tubes having arbitrary cross-section, Purdue Univ., School Aero. Engng. Rep. S-59-1, 53 pp., Dec. 1959.

If an elastic open thin-walled tube is subjected to axial compression, a buckling connected with torsion will occur at a certain load. Similarly, if the tube material is subject to creep, and the applied load is smaller than the elastic buckling load, creep buckling will occur after a certain time.

By making use of a variational theorem, whereby stress rates and strain rates are both varied, AMR **10**(1957), Rev. 3956, author studies this creep buckling problem and determines the creep buckling time as a function of the applied axial load and the initial angle of twist. Large deformation analysis is used, since small deformation analysis is shown to lead to very inaccurate re-

sults. Numerical data are calculated for a symmetric cruciform cross section. No experimental data are available for comparison with theoretical estimates. J. Hult, Sweden

173. van der Neut, A., Buckling and post-buckling behaviour of thermally loaded skin panels, Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 187-212

Author first summarizes his earlier research result ["Buckling caused by thermal stresses," in AGARDograph no. 28: "High temperature effects on aircraft structures," 1958, Chap. 9] that for a rectangular plate under longitudinal compressive load the nonuniformity of the stress in the edge region appears to have a negligible effect on the buckling mode. Since, for a multi-web wing under transient aerodynamic heating condition, the thermal stresses over each skin panel involve high temperature gradient only near the edge region, author concludes that the buckling mode in the isothermal case is a very good approximation for the buckling mode under uneven temperature conditions.

Author then investigates the postbuckling behavior of panels under combined compressive strain and thermal strain. He introduces the wave pattern which was used by Cox and Koiter in early studies of effective width of flat plates. This pattern consists of a developable part over the center of the plate and a double curved part near the edge. Principle of minimum strain energy is used in this analysis. The result shows that the relation between load movements and edge displacement increments beyond the onset of buckling is identical for isothermal and thermal conditions. Author presents charts and tables from which the compressive loads, wave depth, wavelength and stresses can be determined when the edge strain is given. T. H. H. Pian, USA

Vibrations of Solids

(See also Revs. 12, 40, 46, 124, 144, 224, 229, 502, 506, 509, 558)

174. Walton, T. S., and Polachek, H., Calculation of nonlinear transient motion of cables, David W. Taylor Mod. Basin Rep. 1279, 50 pp., July 1959.

In this paper the system of partial differential equations governing the nonlinear transient motion of a cable immersed in a fluid is solved by finite difference methods. This problem may be considered a generalization of the classical vibrating string problem in the following respects: (a) the motion is two-dimensional; (b) large displacements are permitted; (c) forces due to the weight of the cable, buoyancy, virtual inertia of the medium and damping or drag are included; and (d) the cable is assumed to be nonuniform.

The solution of this problem is of practical significance in the calculation of transient forces acting on mooring lines due to the bobbing up and down of ships during the period preceding large-scale explosion tests.

From authors' summary by A. M. Sen Gupta, India

175. Biesterfeldt, H. J., Lange, J. N., and Skudrzyk, E. J., Vibrations of rods at frequencies below their radial resonance, *J. Acoust. Soc. Amer.* **32,** 6, 749–764, June 1960.

The asymptotic vibration laws that describe the high-frequency behavior of complex systems—on the basis of mode masses and the frequency difference between successive resonances and their damping—also give a significant description of the low-frequency behavior of vibrators from their first resonance onwards. Thus, where problems of noise and vibration insulation are concerned, there seems to be no need for more accurate calculation. This paper derives the necessary theoretical background and substantiates the theory by means of a study of vibrating rods.

From authors' summary

176. Krynicki, E., and Mazurkiewicz, Z., Calculation of natural vibrations of a freely supported rod of varying cross section by Ritz Method (in Polish), *Inżyn. Budown.* **16,** 8, 330–333, Aug. 1959.

The problem and the method of solution used are given in the title of the paper. The amplitude of stationary vibrations is expressed by two terms of a trigonometrical series. The given numerical tables facilitate computations of eigenfrequencies of free vibrations. Z. Kaczkowski, Poland

177. Flugge, W., and Zajac, E. E., Bending impact waves in beams (in English), *Ing.-Arch.* **28,** 59–70, Mar. 1959.

This paper deals with the propagation problem of transversal vibrations of elastic beams by including in the governing partial differential equations the rotary inertia and shear effects. The problem is solved by applying the Laplace transform and Fourier sine transform (for stationary phase approximation). The special case of semi-infinite simply supported beam subjected to a bending moment at the hinge is used in order to indicate various methods for presenting the obtained solution in a convenient form for numerical computing. Numerous graphs illustrate the theory.

M. J. Predeleanu, Roumania

178. Cox, H. L., and Boxer, J., Vibration of rectangular plates point-supported at the corners, *Aero. Quart.* **11,** 1, 41–50, Feb. 1960.

Problem is set-up in finite difference form and numerically solved on digital computer. Analysis assumes classical thin-plate theory. Richardson's extrapolation formula is used to improve the results.

Useful numerical results are given for the fundamental frequency and mode shape of rectangular plates with aspect ratios of 1.0, 1.5, 2.0, and 3.0. For a square plate complete data are given for first five frequencies and mode shapes; variation of frequencies with Poisson's ratio is investigated. D. Young, USA

179. Tomson, O. I., Vibrations of coverings consisting of large panels (in Russian), Investigations on the dynamics of constructions (Issled. po Dinamike Sooruzhenii), Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekt., 1957, 142–161; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2974.

Results are furnished for the experimental determination of the frequencies of the natural vibrations and resonance systems found in coverings consisting of large panels, fabricated in ferroconcrete plates in two dimensions. The natural vibrations of the plates and coverings (the vibrations with the lowest frequency) were excited by blows from a wooden beam; the forced vibrations were induced by vibromachines. Coverings of two types were examined: in the first type the plate coverings were being supported by comparatively rigid beams and took on a monolithic character by means of supplementary reinforcement and concrete; in the second type of coverings the stiffness of the supporting beams was less and the monolithic effect was produced by the concrete only. It was established that coverings of the first type could be looked upon as clamped along the contour. When determining the frequencies of the natural vibrations in coverings of the second type very wide divergence in the recorded magnitudes was experienced. It should be noted that the resonance systems were determined not only from the characteristics of the plate being examined but from the characteristics of neighboring plates. Determinations were also made experimentally of the logarithmic decrement of damping of the natural vibrations and of the form of the constrained vibrations.

V. E. Breslavskii

Courtesy Referativnyi Zhurnal, USSR

180. Yu, Y.-Y., Vibrations of elastic sandwich cylindrical shells, AFOSR TN 60-324 (Polyt. Inst. Brooklyn, Dept. Mech. Engng. TN-7), 32 pp., Jan. 1960.

Author presents general theory of sandwich cylindrical shells composed of two face layers of equal thickness separated by an inner core. Paper extends author's previous analysis of elastic sandwich plates. Displacement components which depend linearly on z (the thickness co-ordinate) are assumed. Substitution of the displacement components into the stress equations of motion of classical elasticity yields equations for the three individual layers. For symmetrical and torsional cases, the equations of motion in terms of stress components are transformed into equations of motion in terms of displacement components by a method discussed in author's previous papers. Employing certain restrictive assumptions, author simplifies the general equations. On the basis of these simplified equations, he shows that a change in the order of the relative magnitudes of the radial frequency and of the thickness-shear frequency occurs with shell thickness; for thick shells, the radial frequency is the highest frequency; for thin shells, the thickness-shear frequency is the highest frequency.

Reviewer notes that author's previous work is prerequisite reading for complete understanding of present paper.

A. P. Boresi, USA

181. Goldberg, J. E., Bogdanoff, J. L., and Marcus, L., On the calculation of the axisymmetric modes and frequencies of conical shells, *J. Acoust. Soc. Amer.* **32,** 6, 738-742, June 1960.

Assuming frequency given and small harmonic oscillations, shell equations for axisymmetric modes have only one independent variable, the coordinate of generator. Shell equations may then be written as six ordinary first-order differential equations. By linear transformation originally two-point boundary-value problem is transformed to initial-value problem on which Runge-Kutta method is applied for numerical integration.

To find natural frequency a trial-and-error method is used in which frequency is assumed and determinant for coefficients of outer boundary equations is computed. Frequency is adjusted until determinant becomes zero.

Computations in example show good agreement with earlier known series method.

F. I. Niordson, Denmark

182. Kelly, R. E., Comment on "A simplified expression for the period of nonlinear oscillations of curved and flat panels," *J. Aero/Space Sci.* **27,** 8, 621-622 (Readers' Forum), Aug. 1960.

183. Saunders, H., Wisniewski, E. J., and Paslay, P. R., Vibrations of conical shells, *J. Acoust. Soc. Amer.* **32,** 6, 765-772, June 1960.

Authors determine the natural frequencies of a class of modes of vibration of a thin conical shell built in on the end with the smaller radius and either free or simply supported on the other end. A Rayleigh-Ritz procedure is used, which includes both bending and extensional energies in the analysis. The results of the analysis show that for a sufficiently large number of circumferential nodes, the natural frequency agrees quite closely with the frequency of inextensional vibrations of the cone with the same number of circumferential nodes and simply supported at the edge with the smaller radius. This result is in agreement with the theoretical and experimental work of Arnold & Warburton [*Proc. Inst. Mech. Engrs.* **167,** 62-80, 1953; AMR **7**(1954), Rev. 30] on circular cylinders.

T. K. Caughey, USA

184. Veldhuizen, R., Vibration in the exhaust pipe of a diesel motor (in Swedish), *Tekn. Tidskr.* **90,** 21, 585-588, May 1960.

185. Strunkin, V. A., Vibrations of unevenly heated turbomachine discs (in Russian), *Izv. Vyssh. Uchebn. Zavedenii. Aviats. Tekhn.* no. 1, 165-170, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2980.

An investigation is carried out of the fan-like vibrations of rotating unevenly heated disks of constant thickness. The problem is solved by means of the energetic method. The influence of the rotation and of the uneven heating on the frequency of the deflection vibrations of the disk is computed by adding to the potential energy of the deflection the energy corresponding to the work of internal forces induced by the rotation and the temperature field. The principle of the change of temperature on the radius is taken to be parabolic. It is shown that the uneven heating in conformity with the accepted principle of change of temperature leads to a diminution of the natural frequencies of the vibrations of the disk, while the rotation, as is known, causes an increase. A correlation is found showing under what conditions the influence of the heating is at its optimum. A numerical example is given. The influence of the temperature on the elastic properties of the material is not considered.

D. A. Gokhfel'd

Courtesy Referativnyi Zhurnal, USSR

186. Whitehead, D. S., Vibration of cascade blades treated by actuator disc methods, Instn. Mech. Engrs., Prepr., 1958, 11 pp.

Aerodynamic forces on vibrating blades are investigated starting from consideration of two-dimensional incompressible flow through actuator disk and cascade of blades. Author finds basic equations and discusses solutions for special cases. Limits of theory: time for passing through cascade assumed to be short compared with period of vibration; adjacent blades vibrate nearly in phase. Cascade data for two-dimensional steady flow may be used. Method also allows calculation of effect of inlet fluctuations.

Author finds bending vibration of unstalled blades is always damped for small mean deflection; for large mean deflection he gives a criterion of stability qualitatively supported by published experiments. For bending vibration of stalled blades a criterion of flow-instability (critical value of gradient of total pressure) is derived in accordance with previous theoretical and experimental work of other investigators. But, in general, limit of bending flutter instability is reached before flow instability occurs.

Theoretical instability for torsional vibration is often found, but for these frequencies first limitation (above) is no longer valid.

J. Rehbach, Germany

187. Bohme, H., Fromm, E., and Sittig, E., Vibration of isotropic circular cylinder with vanishing axial component (in German), *Acustica* **10,** 1, 67-71, 1960.

Resonances in isotropic circular cylinders are studied for vibrations with vanishing axial components. They are characterized by an index consisting of two integral numbers (n,p). The series $(n,1)$ degenerates with increasing n into surface waves with wave fronts parallel to the axis.

Measurements on glass and aluminum cylinders confirm the theoretical results.

From authors' summary by H. Parkus, Austria

188. Yatsenko, G. P., Free vibrations of disks of hyperbolic profile (in Russian), *Izv. Kievsk. Politekhn. In-ta* **24,** 314-323, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2965.

The free transverse vibrations of thin disks, symmetrical relative to their middle surface and whose profile is assigned by the equation $h = Ar^{\beta}$, are investigated. The problem is solved by the method of division of the variables. The solution of the equation determining the form of the disk's surface is sought as a trigonometrical series of cosines, the coefficients of which—the functions of the radius—in their turn appear as the sums of infinite stepped series. The equation for the frequency is obtained by utilizing the boundary conditions for a disk, clamped on the internal contour and free on the external one. A numerical example is given for one of the natural vibrations (for vibrations without nodal diameters) of a steel disk of hyperbolic profile ($\beta = -1$).

D. A. Gokhfel'd

Courtesy Referativnyi Zhurnal, USSR

189. Sorokov, S. A., Vibrations of a round arc subjected to a concentrated load (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 192, 154–167, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2966.

This is an investigation of the forced vibrations of a two-hinged round arc using the method of resolution of the transpositions into series by their own functions. A differential equation is derived for the motion of a bar of constant transverse section with a circular axis to cover the case when the axis is nonextensible. Shear and the inertia of rotation of the elements are disregarded. The natural functions and the coefficients of resolution into series are sought. Formulas are derived for tangential displacement, radial displacement and deflection angle of the arc's section, intersecting the forces and deflection moments. Yu. S. Shkenev

Courtesy Referativnyi Zhurnal, USSR

190. Romiti, A., Effects of elastic hysteresis upon the vibration of a rotating shaft (in Italian), *Atti Accad. Naz. Lincei, R.C. Cl. Sci., Fis., Mat., Nat.* (*8*) **26**, 3, 372–378, Mar. 1959.

Author proceeds from the idea that the stability of rotating shafts is due in the first place to the effects of elastic hysteresis. The angular velocity of rotation of the shaft ω and the angular velocity of rotation of the mean deformed fiber θ are introduced in the study. The difference between these quantities is due to the effects of hysteresis, quantitatively determined by an angle 2μ which depends on the properties of materials.

Paper shows, with the aid of mathematical conditions, the cases in which the motion is stable or unstable for shaft velocities lower or higher than the critical revolution velocity.

G. B. Buzdugan, Roumania

191. Kononenko, V. O., Resonance vibrations of a rotating shaft with a disk (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 87–90, July 1958.

Lateral vibrations of a flexible rotating shaft carrying a disk are studied. Internal friction of three types is assumed; that proportional to the absolute velocity of the center of the disk, proportional to the velocity of bending deflection of the beam, and proportional to the angular velocity of the disk. A solution is found for small oscillations. The Routh-Hurwitz criterion for stability is applied. E. Saibel, USA

192. Kogan, I. Ya., The dynamics of elevator cranes used in building (in Russian), Theory and calculation for lifting-transporting (Vopr. Teorii i Raschета Pod'emno.-Transp. Mashin.), Moscow-Leningrad, Mashgiz, 1957, 12–21; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2978.

The vibrations arising in the operation of elevator cranes when moving and checking the load being shifted are the subject of an investigation. A brief exposition is given of the procedure adopted and the results obtained in the experimental investigations. The oscillograms recorded during the experiments indicate the following: the basic frequencies of the natural vibrations of the individual components of the crane were, for all practical purposes, identical; the processes of running and braking the mechanisms of lifting and moving take place usually with increases of velocity conforming to the linear principle; in the mechanisms of turning the crane the running and braking are accompanied by strong variations in the velocity. The energy method is adopted for the theoretical determination of the period of the natural vibrations of the crane. A comparison of results obtained by calculation for the magnitudes of the periods of natural vibrations with the experimental gave satisfactory convergence. A recommendation is made pointing out the necessity when building cranes to give special attention to the correct distribution of mass in order to ensure a minimum duration for the period of natural vibrations. Any increase in the duration of these vibrations leads to an increase of the amplitudes of the vibrations. The existence of vibrations of sufficiently large amplitudes makes the work of the cranesman more difficult, more especially when large constructural components are in question, for these require precise positioning capacity in the lifting and lowering components of the crane. To achieve a reduction in the period of natural vibration in the horizontal plane the principle has been accepted in a number of recently constructed tubular tower cranes, heavy excavators and portable cranes of distributing the mass as near as possible to the axis of rotation. With regard to vibrations in the vertical plane it is desirable to distribute all the mechanisms and counterweights in high tower cranes as low down as possible.

V. M. Makushin

Courtesy Referativnyi Zhurnal, USSR

193. Kato, S., Theoretical research on chatter vibration of lathe tools, *Mem. Fac. Engng., Univ. Nagoya* **10,** 2, 117–174, Nov. 1958.

Author offers a theory which explains the annoying phenomenon of self-excited chatter frequently observed in metal cutting as being one of retarded action due to a time lag (b) of the chip-tool friction process against the process of workpiece shearing. Main part of paper treats the case of a rigid tool orthogonally cutting a vibratory workpiece of mass m, stiffness k and damping c. Neglecting force and motion components parallel to direction of cut and considering so-called primary chatter (no effect of surface undulations), equation of motion simplifies to $m\ddot{x} + c\dot{x} + k(x + a) = F\{d - x(t - b)\}$ where x is workpiece displacement, F the cutting force, d the feed, t the time and $a = F\{d\}/k$ the workpiece displacement under chatter-free conditions. From this, stability criteria and frequency equations are derived. Linear case $F = Kd_b$ is treated by ordinary complex analysis, and nonlinear case $F = Kd_b - K_3 d_b^3$ by method of Kryloff-Bogoliuboff, K and K_3 being constants and $d_b = d - x(t - b)$.

Numerical evaluation of analytical results shows good agreement with many observations from practice and experiments. Vanishing cutting force in domain $x > d$ has a limiting effect on vibration amplitude, as shown by phase-plane method of Jacobsen. Theory is readily extended to include effect of surface undulations (regenerative chatter). Paper concludes with similar analysis on alternative case of a rigid workpiece being cut by a flexible tool.

In reviewer's opinion, this paper is a valuable contribution to the chatter problem; however, he would have wished for a shorter presentation and a complete de-dimensionalization of the analysis. E. Fredericksen, Denmark

194. Osipov, A. I., The relaxation of the vibrational motion in an isolated system of harmonic oscillators, *Soviet Phys.-Doklady* **5,** 1, 102–104, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130,** 3, 523–525, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

195. Moiseev, N. N., On the theory of vibrations of elastic bodies with liquid cavities, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 5, 1233–1254, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

This is a mathematically elegant study of the influence of liquid-filled cavities upon the vibrations of elastic bodies. It is assumed that the problem is linear, the fluid ideal and incompressible and the elastic body is a beam. At first, the free vibrations of a beam with cavities completely filled with liquid are studied by the Ritz method. The problem reduces to the analysis of flexural vibrations of an "equivalent beam" having the same bending rigidity, but a changed mass per unit length. Secondly, flexural vibrations of a beam with cavities partially filled with liquid are studied, which leads to an additional natural frequency spectrum and additional principal modes. The motion of the beam-fluid system is described by a system of two integrodifferential equations, and the solution of the problem reduces basically to

constructing Neumann operators, finding sets of functions for the Ritz summations and then setting up and solving a homogeneous system of algebraic equations.

The third section of the paper deals with some basic general problems of the theory of arbitrary vibrations of the system, where the concept of function space is introduced. The question of the stability of a beam, inside which there is a liquid mass having a free surface, reduces to the study of the stability of the same beam without fluid but under the action of another system of external forces. A proof of the existence of principal modes is conducted, and it is also proven that the system of principal modes of vibration is complete within the totability of the function spaces, which substantiates the use of the Ritz method.

M. I. Yarymovych, USA

196. Hu, H.-C., and Tsoon, W.-S., On the flexural vibrations of a pipe line containing flowing fluid, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur; 1957, 203–216.

The equation of flexural vibrations of a pipe containing a flowing fluid presents analytical difficulties because it is not self-adjoint.

The authors show that for the case of simply supported or free ends, the natural frequencies are real, and that they are identical for direct and reversed flow. The normal modes are conjugate for direct and reversed flow. A near analog of Maxwell's reciprocal theorem is proved for the forced vibrations with flow in either direction. For an infinitely long pipe, authors show that flexural waves of certain frequencies can propagate only in the direction of flow.

Forced vibration from harmonic loads is treated by eigenfunction expansion, considerable ingenuity being used to establish the validity of the expansion.

C. T. West, USA

Wave Motion and Impact in Solids

(See also Revs. 84, 88, 177, 206, 256, 285, 367, 368, 514)

Book—197. Davids, N., editor, International symposium on stress wave propagation in materials (Pennsylvania State Univ., University Park, Pa., June 30, July 1–2, 1959, sponsored by Office of Ordnance Research, U. S. Army), New York, Interscience Publishers, Inc., 1960, 337 pp. + 234 figs. + 249 refs. $10.

Book contains 15 papers on current progress in several scientific fields of stresses with high rates of loading, mainly of impact nature. Main fields discussed are: stress propagation in earth layers and in viscoelastic materials, metallurgical effects, scabbing, rock breakage, and armor penetration. Authors and titles of papers are:

V. R. Thiruvenkatachar: Recent research in stress waves in India.
C. W. Curtis: Propagation of an elastic strain pulse in a semi-infinite bar.
C. L. Pekeris: Propagation of seismic pulses in layered liquids and solids.
H. Kolsky: Viscoelastic waves.
M. M. Frocht: Studies in dynamic photoelasticity with special emphasis on the stress-optic law.
Sudhir Kumar: Edge waves in plates.
R. J. Eichelberger: Effects of very intense stress waves in solids.
James R. Kymer: Experimental studies in armor penetration.
K. W. Hillier: A review of the progress in the measurement of dynamic elastic properties.
E. H. Lee: The theory of wave propagation in anelastic materials.
K. B. Broberg: Some aspects of the mechanism of scabbing.
John S. Rinehart: The role of stress waves in the comminution of brittle, rocklike materials.
Norman Davids: Some problems of transient analysis of waves in plates.
H. Schardin: Cinematography of stress waves.
Yasuo Satō: Analysis of dispersed surface waves.

The authors are experts in their fields, and all papers treat their subjects in an authoritative manner, giving a clear picture of the present status. Most of the numerous references give only the author and locus, only comparatively few give the title also. Giving the titles in all cases would have enhanced the usefulness of the references.

K. J. DeJuhasz, USA

198. Salvadori, M. G., Skalak, R., and Weidlinger, P., Waves and shocks in locking and dissipative media, *Proc. Amer. Soc. Civ. Engrs.* **86,** EM 2 (*J. Engng. Mech. Div.*), 77–105, Apr. 1960.

The propagation of stress waves in two types of anelastic media is considered. The first type of material is a locking medium which is elasto-plastic for low stresses and behaves as an incompressible rigid solid after it has been compressed to a certain maximum strain. Supersonic shock waves, subsonic plastic waves with an elastic precursor, or purely elastic waves may be generated in such a medium depending on the stress levels attained.

The second type of medium considered exhibits a constant modulus of elasticity on initial loading and a second larger modulus on unloading. When a pressure pulse is set up on such a medium an unstressed state will eventually be reached but permanent displacements will occur.

H. Kolsky, England

199. Duff, G. F. D., The Cauchy problem for elastic waves in an anisotropic medium, *Phil. Trans. Roy. Soc. Lond* (*A*) **252,** 1010, 249–273, Feb. 1960.

Author presents a formal solution, using Fourier transforms, of the initial-value, or Cauchy, problem of the propagation of elastic waves in a homogeneous anisotropic solid. For an isotropic solid, the resulting disturbance at a field point, due to an initial sharp and concentrated disturbance, consists of an initial sharp pressure wave, a continuous wave, and a final sharp shear wave. For an anisotropic solid the solution again consists of a continuous wave and a number of sharp waves, but their detailed nature may be very different and much more complicated. The continuous wave may arrive at a field point in advance of the first sharp wave, though it always terminated with the last sharp wave. The number of sharp waves may not exceed 75. A detailed examination of the geometry of the three sheets of the wave surface, corresponding to the three modes of the solution, is given and qualitatively determines the nature of the solution.

From author's summary by P. Seide, USA

200. Ang, Dang Dinh, Elastic waves generated by a force moving along a crack, *J. Math. Phys.* **38,** 4, 246–256, Jan. 1960.

Author assumes plain strain and considers an existing semi-infinite crack. Starting from the tip of the crack at zero time, a singular force, represented by a delta-function of normal stress at the crack edges, moves along the crack at constant velocity. This dynamic boundary-value problem is solved by using Laplace transforms of the wave equations for dilation and for shear waves. Author arrives by sophisticated treatment at a solution in terms of complex integrals. The solution exhibits the expected wave fronts of dilatational wave, shear wave, head wave, and surface wave. Author notes that if the disturbance moves at the velocity of the surface wave (Rayleigh wave) then amplification of the surface wave front occurs. Reviewer did not fully understand how the boundary-value problem treated in the paper is related to crack propagation, but author may well be right.

F. C. Roesler, England

201. Chakraborty, S. K., Rotational waves in a viscoelastic medium due to a twist on the surface of a spherical cavity (in English), *J. Sci. Engng. Res., India* **2**, 2, 195–200, July 1958.

Kelvin solid with twist about axis through center of spherical cavity whose surface moves as rigid body is investigated. Dilatation zero and spherical surfaces concentric with cavity also twist rigidly. Steady-state oscillatory solution is sought, and impulsive case evaluated by Fourier integral. Approximation of neglecting powers of viscosity coefficient relative to elastic modulus is included. Increased decay of waves due to viscoelastic effect is deduced. E. H. Lee, USA

Soil Mechanics: Fundamental

(See also Revs. 223, 540)

Book—202. Kezdi, A., Soil mechanics, Vol. 1 [Talajmechanika, 1], 2nd rev. ed. Budapest, Tankonyvkiado, 1959, 618 pp. 63.20 Ft.

This is a comprehensive treatise on the title subject, intended primarily to supplement formal undergraduate instruction offered in the engineering schools of the author's country and also to bring practicing engineers up to date on the subject. This first volume is in two parts, the first on physical properties of soils; the second part on theoretical soil mechanics. A second volume on engineering applications will follow. Treatment is clear and thoroughgoing. In areas of recent (and often incomplete) developments, viewpoints and contributions of various authors are carefully screened and presented in coherent sequence. Good examples of this approach are the chapters on stability of slopes and elastic stress distribution in soil masses, for which well-balanced treatments are offered, which include the author's original contributions to these fields. Reviewer feels that this book is an example of outstanding treatise writing. O. Hoffman, USA

203. Ormsby, W. C., The role of surface tension in determining certain clay-water properties, *Bull. Amer. Ceram. Soc.* **39**, 8, 408–412, Aug. 1960.

The importance of the surface tension of the liquid phase in controlling the plasticity and related properties of clay-water systems is critically reviewed. The experimental evidence supporting the so-called stretched-membrane theory of plasticity is re-examined in some detail and is found to be incomplete. Generalizations based on this evidence are therefore open to question.

From author's summary

204. Gibson, R. E., A one-dimensional consolidation problem with a moving boundary, *Quart. Appl. Math.* **18**, 2, 123–129, July 1960.

Solution is given for one-dimensional consolidation of a clay layer. Equation satisfied by excess water pressure u in pores of homogeneous saturated clay layer bounded by planes $x = 0$, $b(t)$ is

$$cu_{xx} = u_t - \gamma(db/dt)$$

where c is coefficient of consolidation and γ the submerged density. Using integral equations, formal solutions are obtained which satisfy

$$u_x(0,t) = 0,\ t > 0$$

$$u[b(t),t] = 0,\ t > 0$$

$$u(x,0) = f(x),\ 0 < x < b(0),$$

where $b(t)$ and $f(x)$ are given functions.

E. H. Mansfield, England

205. Horn, J. A., Computer analysis of slope stability, *Proc. Amer. Soc. Civ. Engrs.* **86**, SM 3 (*J. Soil Mech. Foundations Div.*), 1–17, June 1960.

A computer program has been written that can solve a great variety of slope stability problems. It is possible to analyze a slope with any surface configuration, with one or two soil strata in any pattern, and with or without water table, pore pressures, increasing cohesion with depth, tension cracks, rigid base or loads anywhere on the surface. Given these properties of a slope, the computer will automatically search out the minimum factor of safety, solving the entire problem in from one to three minutes.

From author's summary

Soil Mechanics: Applied

(See also Revs. 119, 202, 223)

206. Smith, E. A. L., Pile-driving analysis by the wave equation, *Proc. Amer. Soc. Civ. Engrs.* **86**, SM 4 (*J. Soil Mech. Foundations Div.*), 35–61, Aug. 1960.

There are a great many different pile-driving formulas in use, and engineers have never been able to agree as to which one is best. This situation has arisen primarily because, until recently, the mathematics of pile-driving action could not be solved in any practical manner. As a result, all pile-driving formulas are partly empirical and, consequently, apply only to certain types or lengths of pile. This paper is presented with the purpose of giving engineers a mathematical method of wider application, depending on the use of electronic computers and numerical integration. The method is also applicable to other impact problems.

From author's summary

207. Hegedus, E., and Rowe, R. S., Drag coefficients of locomotion over viscous soils, *Proc. Amer. Soc. Civ. Engrs.* **86**, SM 2 (*J. Soil Mech. Foundations Div.*), 63–75, Apr. 1960.

See AMR **12**(1959), Rev. 5540.

208. Buts'ko, Z. N., Determination of the bearing capacity of granular media (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **26**, 216–227, 1958.

In the book by W. W. Sokolovsky on the "Statics of a granular medium," a method was expounded for the determination of the bearing capacity of such a medium. Solution of pertinent problems reduces itself to a numerical solution of a system of differential equations, which present considerable difficulties.

To facilitate practical applications of the discussed method, solutions for various parameters involved have been worked out, and numerical tables computed.

From author's summary by M. G. Bekker, USA

Processing of Metals and Other Materials

(See also Revs. 68, 193, 231)

209. Kaga, H., and Yaji, S., Study on stretch forming method of sheet metal, *J. Mech. Lab., Japan* **5**, 2, 89–95, 1959.

This is an interesting study of the title problem, both experimental and theoretical. Authors have assumed a stress-strain law of the form $\sigma = F\varepsilon^n$, both in tension and compression, and have allowed for the Bauschinger effect, during bending under tension. Justification of their analysis is given by its good correspondence with their experimental results, in which they compared the measured strains on inner and outer surfaces of the sheet with those predicted theoretically, for varying applied tensions. Paper is written in fair English, although certain phrases need liberal interpretation. J. M. Alexander, England

210. Wain, H. L., Henderson, F., and Johnstone, S. T. M., Some experiments on the effect of rolling temperature, pre-strain and strain rate on the ductility of chromium, Aero. Res. Lab., Melbourne, Austral. Rep. Met. 36, 14 pp., May 1960.

Chromium has been "cold-rolled" at several temperatures in the range 300°–1050°C. No effect of rolling temperature on ductility was evident, with all ductile/brittle transition temperatures lying between −70° and −93°C. Also, these low transition temperatures were achieved without the development of any marked preferred orientation. The ductility of recrystallized chromium was considerably improved by rolling at a temperature slightly above the transition temperature ("pre-straining"), but experiments to determine if this improvement was maintained after subsequent high-temperature vacuum-annealing were inconclusive. A rise in transition temperature of 80°C occurred on increasing the rate of loading during testing from 2×10^{-3} to 2 in./min.

From authors' summary

211. Samuels, L. E., Modern ideas on the mechanical polishing of metals, *Research, Lond.* **13,** 9, 344–349, Sept. 1960.

A widely accepted view is that mechanical polishing occurs by a process of surface flow producing a drastically-altered, amorphous-like layer known as the Beilby layer. However, evidence obtained recently indicates that this is not so, at least when metals are polished by the use of fine abrasives. The new evidence indicates that polishing occurs primarily by cutting, producing a crystalline, but plastically deformed surface.

From author's summary

212. Colonnetti, G., Relaxation and "strengthening" (of metals) (in French), *C. R. Acad. Sci., Paris* **249,** 5, 599–600, Aug. 1959.

Fracture (Including Fatigue)

(See also Revs. 79, 200, 230, 580)

213. Lean, J. B., Plateau, J., and Crussard, C., Contribution to the study of the mechanism of brittle fracture in mild steels (in French), *Rev. Métall.* **56,** 4, 427–452, Sept. 1959.

Tensile tests with specimens of mild steel with 0.04% C at temperatures of +150° to −210°C show that down to −150° ultimate strength and upper and lower yield point of cylindrical specimens increase, if velocity of straining, 1.4×10^{-5} to 3.8×10^{-1}/sec, increases, but that elongation and reduction of area decrease. As temperatures become lower reduction of area and elongation decrease to a small percentage in a narrow range, transition range being at lower temperatures at low velocity of straining, so that curves cross. Upper yield point increases more at low temperatures than ultimate strength, stresses being equal between −50° (for 3.8×10^{-1}/sec) and −150°C (for 1.4×10^{-5}/sec).

Tensile tests with notched specimens showed a similar decrease in reduction of area as velocity of loading increased from 0.05 to 1510 kg/mm²/sec; lower velocity being amended with lower transition temperature. This was about 60° higher than that of the cylindrical specimens. Activation energy calculated from this transition temperature was proportional to absolute temperature. If notched specimens had a ductile fracture, breaking was in the narrowest area through the deformed zone; if fracture was brittle, it followed the Lüders lines, in a bow beside the narrowest area.

If breaking begins in the limit between Lüders lines and the non-plastic volume, deformation in this zone can reach 10%, resulting in a cleavage fracture. If this mechanism of fracture does not take place, fracture occurs mostly in the zone of heterogeneous stresses.

A. Kirsch, Germany

214. Rolfe, S. T., Lynam, T. M., and Hall, W. J., Studies of the strain distribution in wide plates during brittle fracture propagation, Ship Structure Committee Rep. 118; Washington, D.C., National Research Council, Dec. 1959, 64 pp.

As part of a study of fracture in ship plates, the strains near the tips of propagating cracks were measured. The cracks were moving across 3/4 in. thick, 6 ft. wide plates at speeds of 2000–4500 fps. The plates were made of as-rolled, semi-killed steel subjected to an initially uniform stress of 19,000 psi at −10 to 0°F. The strains were measured by strategically placed groups of resistance strain gages; a very complete description of the data, and the strain-distributions, for six tests is given in the report. It was found (perhaps not unexpectedly) that the high elastic strains near a crack tip drop to the value of the average stress in the plate within about 8–10 in. ahead of the crack. As a crack moves along, the strain pattern moves with it, changing only near the plate edges. Strain rates up to 109 per sec were observed.

J. J. Gilman, USA

215. Hori, M., An analysis of flexural failure of concrete from the standpoint of stochastic theory, Proc. Second Japan Congress on Testing Materials, Kyoto, Japan, Oct. 14–15, 1958; Japan Society for Testing Materials, Kyoto, 1959, 174–177.

Seven series of flexural failure tests were carried out on cement mortar specimens 40 × 40 × 160 mm. Bulk density and dynamic modulus of elasticity were determined for each specimen. Variation of these characteristics was small, so that specimens may be regarded as uniform as far as structure-insensitive properties are concerned. Specimens of first series were loaded to failure with a constant rate of loading. Specimens of the remaining series were subjected to various sustained loads not less than 85 per cent of flexural strength. Fracture was obtained in most cases within two minutes after application of sustained load.

Scatter shown by sustained load tests was substantially wider than that of the static tests. Attempt was made to analyze results statistically according to stochastic theory. Author concludes that scatter of sustained-load tests is an inherent characteristic of the material. The theory of stochastic processes is therefore approximately applicable.

H. K. Hilsdorf, USA

216. Methven, T. J., and Fairhead, B., A correlation between rain erosion of Perspex specimens in flight and on a ground rig, Aero. Res. Counc. Lond. Curr. Pap. 496, 24 pp., 1960.

The amount of surface erosion on Perspex was measured for specimens flown on an aircraft in rain and tested on a whirling arm ground rig in artificial rain. Specimens were compared at 400 knots and similar rain concentrations.

Results show that 1 in./hr rain in flight gives similar erosion to 1.5 in./hr on the ground rig; this may be due to the greater range of droplet sizes found in flight.

From authors' summary

217. Carter, D. J., Jr., A preliminary investigation on the destruction of solid-propellant rocket motors by impact from small particles, NASA TN D-442, 25 pp., Sept. 1960.

An investigation was conducted to determine the effects of impacting spherical projectiles on simulated solid-propellant rocket motors over a range of ambient pressures from sea level to 0.12 inch of mercury (approximately 125,000 feet). Spheres ranging from 1/16 to 7/32 inch in diameter were fired into simulated rocket motors containing T-22 propellant. Simulated case thicknesses varied from 1/50 to 1/8 inch. Within the scope of this investigation, it was found that ignition and explosive destruction of simulated steel-case rocket motors could result from impacts by steel spheres at the lowest attainable pressure.

From author's summary

218. Strunin, B. M., On the statistical theory of strain in metals, *Soviet Phys.-Doklady* **4,** 2, 439–442, Oct. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **125,** 4, 790–793, Mar./

Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Stressed specimen is divided into linearly stressed macrovolumes and each macrovolume is divided into elements. Elastic potential energy of an element is assumed to be normally distributed with mean and standard deviation depending upon average relative deformation. Further theory is based upon assumption that plastic deformation (or rupture) occurs when elastic potential energy of a fixed proportion of elements has surpassed a certain critical value N. G. Blomqvist, Sweden

219. Chaevskii, M. I., Effect of fused tin on the fatigue strength of steel specimens with stress concentrators, *Soviet Phys.-Doklady* **4,** 1, 207–209, Aug. 1959. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **124,** 5, 1049–1051, Jan./Feb. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Special fatigue test specimens made of carbon steel with stress concentrators were tested in a machine for cyclic bending at normal and elevated temperatures in the air, with fused but unpickled before-hand—and with fused and pickled—specimens. Below a certain stress level fused tin adds to the fatigue strength. As an explanation the action of surface-active substances, the healing effect of "groove vessel" and protection from oxidation by fused tin are suggested. Diagram of test results at 300°C is produced.

Reviewer believes that the results obtained are of interest but given explanations of the observed phenomenon are very scarce and suggestive only. B. Kuzmanovic, Sudan

220. Fisher, W. A. P., Programme fatigue tests on notched bars to a gust load spectrum, Aero. Res. Counc. Lond. Curr. Pap. 498, 19 pp., 1960.

A series of program fatigue tests in axial loading was made on notched bars machined from extruded alloy to D.T.D.363A. The load spectrum represented a simplified truncated gust spectrum. The alternating load in each program was steadily increased to a maximum (corresponding to a 27.5 ft/sec gust) and down again. The program was repeated until failure of the specimen. The average number of programs to failure was in each case greater than that predicted by the Miner hypothesis $\Sigma \frac{n}{N} = 1$.

Further tests are recommeded, in which material, type of specimen, and order of loading are varied.

From author's summary

221. Kawada, Y., Sekido, Y., and Sasaki, S., Some experiments on the fatigue life under double and triple stresses, *Bull. JSME* **3,** 10, 275–281, May 1960.

222. Fisher, W. A. P., Some fatigue tests on notched specimens with programme loading for a "ground-attack" aircraft, Aero. Res. Conc. Lond. Curr. Pap. 497, 16 pp., 1960.

A series of program loading tests was made in a hydraulic fatigue testing machine to check the validity of the Miner Cumulative Damage Hypothesis for a structural light alloy notched specimen in axial tension. Test loads were based on an accelerometer load spectrum and calculated according to ultimate factors of 11, 13 and 15. Additional tests were made with higher peak loads.

For this type of specimen and for this shape of load spectrum the Miner Hypothesis is somewhat conservative.

From author's summary

Experimental Stress Analysis

(See also Revs. 120, 121, 145, 162, 187, 238, 248, 262, 435)

Book—223. Symposium on the observation of structures. Vol. I. Opening speeches, general report, discussion. Vol. II. Transactions and papers (in English and French), Lisbon, Laboratorio Nacional de Engenharia Civil, 1955, Vol. I, vii + 228 pp.; Vol. II, vii + 1027 pp. **$10.50 for both volumes.**

Vol. I contains general report by M. Rocha, J. Ferry Borges and J. L. Serafim based on individual papers presented in Volume II and a discussion of the individual participants on various subjects related (1) to "description and characteristics of the apparatus and method for the measurement of (a) displacements, opening of joints, cracks, rotations and (b) of strains, stresses, forces, temperatures and humidity;" (2) to "evaluation of the properties of materials;" and (3) to "programmes, descriptions and interpretation of results of observation (a) of dams and (b) of bridges and other structures."

Volume II contains 54 contributions to three main subjects: Measurement of permeability, capillarity and resulting porosity (M. van Laethem); thermic auscultation of dams by means of thermocouples, melting ice being used as temperature standard (J. Chapelle); the same subject solved by means of pendulums, clinometers and acoustic strains (G. Willm); determination of stresses in an arch dam from observed strains with particulars about instrumentation used by Bureau of Standards (A. Warren Simmonds); electric resistance strain gage measurements on long welded rails (U. Schlumpf); strength distribution as factor of quality control of concrete, suitability of Gaussian curve (R. Shalon and R. C. Reinitz); techniques for testing roads, developed by the Road Research Laboratory, London (A. C. Whiffin); torque meters to determine damage in concrete (R. Comolet); determination of damage in reinforced concrete by ultrasonic means (K. Wesche); failure tests of coated railway bridge (A. Lazard); stresses and deformation in arch dam (E. Reinius); apparatus for structure auscultation (E. Dehan and E. Demol); measurement of creep losses of prestressed-concrete bridge at Sclayn (H. Louis and E. Dehan); auscultation of steel bridge in Belgium (E. Dehan and J. Thonnard); temperature measurement with thermistors (semi-conductors characterized by high negative temperature coefficient) in concrete (K. E. C. Nielsen and I. Schill); photogrammetric measurements of deformation of structures (C. Moser and W. R. Schriever); determination of modulus of elasticity of rock by geotechnical means (hydraulic press, thin cushion, radial press and testing chamber), geophysical (geoseismical) and laboratory methods (B. Kujundzic); measurement of pore-water pressures and its application (L. F. Cooling); testing techniques to measure existing stresses in building constructions (N. Davey); strain measurements on two buildings (S. R. Sparkes & J. C. Chapman); strain measurements at three Belgian steel bridges (F. Hebrant, H. Louis and A. Soete); measurement of deformation by photoelastic methods in elastic-plastic structures (G. Grandori); deformation in reinforced-concrete structures measured by strain gages fixed to steel (J. Bossi and G. Moravia); deformation measured by surveying methods (J. Neviere and P. Blanchet and M. Mermin); crack measurements in reinforced concrete (S. Soretz); determination of bearing strength of airfield runways by strain gages (R. Lorin); photoelastic stress analysis by use of coating (F. Zandman); dynamic effects measured by vibrating strings with example of oscillogram (G. Jacubowitz and J. Bellier); vibrating string dynamometer for measuring stress in parallel prestressing cable (E. Petit and J. Bellier).

Compressibility of foundations under dams (J. Bellier and W. ter Minassian); experimental proof of reliability of vibrating strings (J. Bellier and L. Sabbat); effect of longitudinal joint on stresses at base of large arch dam (J. M. Raphael); methods and apparatus used in Portugal for observation of dams (M. Rocha, J. L. Serafim and A. F. da Silveira); dam displacements observed by pendulums as compared with geodetic methods (A. F. da Silveira); joint movements in dams in Portugal (A. F. da Silveira); strain measurements in Portuguese concrete dams; provision of strain meters inside concrete (J. L. Serafim); measurements of total displacements of these dams by geodetic methods (O. V. Rodrigues); precise geometric levelling for observation of struc-

tures (A. F. de Lemos); two new recording deflection indicators (G. Dawance); deformation of concrete lining ring under different water pressure (L. M. Lobo); torsion in suspension bridge stiffening trusses (S. Shore); observation of reinforced-concrete structures, particularly bridges in Portugal (M. Rocha, J. F. Borges and J. Marecos); observation of road and railway embankments and slopes by special levelling rod (U. Nascimento and A. Simoes); measuring discharge of infiltrations through some dams and their foundations (A. P. Carlos, L. J. Folque and A. S. Nunes); strain measurements on Telford's suspension bridge at Conway, Wales, built 1826 (J. B. B. Owen); measuring devices (uplift, horizontal deflection, tilt, vertical and horizontal shrinkage and temperature) used at Scottish dams (C. M. Roberts); safety control of arch dams by observations (A. C. Xerez); settlements of canal aqueduct in connection with irrigation (A. da Palma Caelos, L. J. Folque and A. S. Nunes); dynamic measurements by strain gages embedded in concrete (H. W. Koch); strain gages for full scale testing of structures (H. D. Morgan and K. R. McLachlan); sensitivity of strain gages to transverse deformation (A. U. Huggenberger); evaluation of safety of old metallic bridges (J. F. Borges, J. Marécos and L. da Cunha Ferraz); and observation of concrete structures, principal methods and instruments based on 25-years' experience (A. U. Huggenberger).

P. W. Abeles, England

224. Wood, A. F. B., On the photoelastic examination of vibrating bodies and the photoelastic effect in optically active media, *J. Mech. Phys. Solids* **8,** 1, 26–38, Jan. 1960.

The interpretation of the photoelastic stress patterns of vibrating bodies is discussed, with particular reference to quartz crystals. An expression is derived for the change in velocity of a light wave propagated along the optic axis due to stresses acting in the plane normal to this axis. Such stresses should cause an increase in the effective rotary power and this is verified by experiment. This result offers an explanation of phenomena observed by earlier workers.

From author's summary by D. Kececioglu, USA

225. Shimada, H., Photoelastic investigation of the stresses in bars with reinforced semi-circular notches on both sides under tension, *Technol. Rep. Tohoku Univ.* **24,** 2, 25–32, 1960.

The object of the work described was to obtain information about the stresses in reinforced plastic bars. Experiments were carried out under tension on a bar with composite reinforced semicircular notches. The bars were of epoxy resin reinforced semiduralumin. The stresses were determined photoelastically in the epoxy resin part of the bar. The relation between maximum shear and the width of the bar and reinforcement was determined. The empirical formulas which give the maximum value of maximum shear stresses are suggested. From author's summary

226. Schwieger, H., and Haberland, G., Photoelastic investigation of a cantilever plate with linearly varying thickness (in German), *ZAMM* **39,** 3/4, 85–100, Mar./Apr. 1959.

The photoelastic two-sheet method, in conjunction with an evaluation method developed by the authors, has been used to investigate finite cantilever plates the flexural rigidity of which varies from place to place. From the photoelastic parameters such as the maximum twisting moments and the directions of the principal bending moments, step-by-step the twisting moments, the trajectories of the principal bending moments, and finally the equivalent plate moments could be determined. From the latter the bending moments and the bending stresses are easily obtained. This experimental method marks a certain advance in experimental mechanics, and may serve to control or stimulate theoretical computation of the structures concerned; on the other hand it may be used to solve problems too complicated for mathematical analysis.

G. Sonntag, Germany

227. Lee, I. K., The application of the vibrating wire measuring principle to the measurement of earth pressure, *Austral. J. Appl. Sci.* **11,** 1, 65–79, Mar. 1960.

Fundamental phases of the vibrating-stretched-wire principle applied to pressure gages are considered in this paper. Author shows the influence of length and tension on frequency and describes the characteristics of two pressure gages, one built with a gage length of 1.9 in. and the other with a gage length of 4 in. Calibration and sensitivity are studied in detail. The remarkable long-term stability of these gages is pointed out.

A. J. Durelli, USA

Material Test Techniques

(See also Revs. 79, 219, 574)

228. Koster, W., and Scherb, J., Determination of the Poisson ratio during elastic and small plastic deformation (in German), *Z. Metallk.* **49,** 10, 501–507, Oct. 1958.

Poisson's ratio of rhodium and iridium has been found to be 0.26. The stress-strain curve in the elastic region consists of two straight lines with different slope. Only little change of Poisson's ratio is observed in this region. At beginning of plastic flow Poisson's ratio may reach values up to 0.5. A small plastic deformation (~1%) has no effect on Poisson's ratio. For silver, Poisson's ratio decreases at high deformations. The behavior of Poisson's ratio at low stresses is discussed.

From authors' summary by K. Angervo, Finland

229. Franz, H., Method for the determination of the Poisson ratio (in German), *Z. Metallk.* **49,** 10, 510–516, Oct. 1958.

The direct and indirect methods for determination of Poisson's ratio are reviewed. The advantages and disadvantages of the different methods are compared.

From author's summary by K. Angervo, Finland

230. Serensen, S. V., and Kotov, P. I., On method of thermal fatigue testing, *Indust. Lab.* **24,** 9, 1221–1232, Sept. 1959. (Translation of *Zavod. Lab., USSR* **24,** 9, 1097–1107, Sept. 1958 by Instrument Society of America, Pittsburgh, Pa.)

This purely review article is incomplete and based mostly on Russian work (25 out of 40 references are from U.S.S.R. publications).

Thermal fatigue is defined as failure in the plastic range of a material due to fluctuating stresses either from thermal cycling alone or in conjunction with applied stresses. It is pointed out that this is a nonstationary process, i.e. the local plastic strain distribution changes with time.

Compared with mechanical fatigue failure in the elastic range, additional factors influence the failing stress level, depending on temperature (reduction in elastic limit, tensile strength, elastic moduli and coefficients of thermal expansion) and others depending on time, temperature and stress levels (creep, recrystallization and phase change).

Correlation is attempted of experimental values with results from elastic theory, using "equivalent" elastic strains; also, with fatigue tests in the plastic range without thermal cycling. It appears that these attempts fail, it being impossible, reviewer believes, to distinguish between the relative contributions of the above parameters and their interaction. Miner's cumulative damage law is used.

Some relatively simple test set-ups are shown, as well as experimental results.

The report should be used with caution in view of the largely unproved assumptions made. E. Pribram, England

231. Oosterkamp, W. J., Proper, J., and Teves, M. C., X-ray inspection of hot steel billets during rolling, *Philips Tech. Rev.* **21,** 10, 281–285, 1959/60.

Properties of Engineering Materials

(See also Revs. 105, 212, 215, 219, 442, 456, 534)

Book—232. McClintock, R. M., and Gibbons, H. P., Mechanical properties of structural materials at low temperatures, Washington, D. C., National Bureau of Standards, Monograph 13, 1960, x + 180 pp. $1.50.

The tensile strength, yield strength, tensile elongation, and impact energy of about two hundred materials, metallic and nonmetallic, are given graphically as functions of temperature between 4° and 300° Kelvin. From authors' summary

233. Krisch, A., Influence of low temperatures on the strength in a biaxial field (in German), *Arch. Eisenhuttenw.* **31,** 1, 19–24, Jan. 1960.

Uniaxial tension and combined axial and circumferential tension tests on steel at room temperature, −30°C and −70°C have been made and results at yield point and ultimate strength are compared on basis of deformation energy hypothesis. Agreement is within a few per cent throughout temperature range.

G. G. Meyerhof, Canada

Book—234. Frenkel', Ya. I., Introduction to the theory of metals, 3rd ed. (in Russian), Gos. Izd-vo Fiz.-Matem. Lit., Moscow, 1958, 368 pp. + illus. 11 r 60 k; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3322.

This book is the third edition of a monograph written by the author on the basis of his original work and lectures dealing with the essential questions in modern concepts of the physics of metals. In the first part, devoted to the electronic theory of intermolecular forces, will be found calculations for the equations for the state of metals, and theoretical evaluations for the compression and hardness of metals and ionic crystals. The second part gives information on the zonal theory of dielectrics and metals; the third, on the molecular-kinetic theory of solid and fluid bodies. A detailed examination is made of diffusion in solid bodies, of questions relating to the formation of holes (voids) and dislocated (internodal) atoms, and of the part played by voids in the mechanism of the fusion of a crystal. The fourth part discusses the properties of regular and disintegrating alloys. The fifth part is concerned with the problem of the hardness and plasticity of metals.

The divergence in the theoretical and technical hardness of solid bodies is explained by the presence of defects in the crystalline structure. The existence of these defects is confirmed by analysis of the relation of the hardness of the samples to their dimensions. There is a brief exposition of the static theory of hardness, and the basic properties of microcracks come under consideration. The presentation of dislocations as the original elements in plastic deformation is developed. An investigation is made, with the aid of single-dimensional models of atomic chains (Frenkel-Kontorov models), of the properties of translating longitudinal (edge), translating transverse (spiral), and orienting (twinning) dislocations. The energy and length of the free run of the dislocation and the relation to velocity are evaluated. The dislocation mechanism of plasticity is compared with the diffusional, corresponding to a slower transposition of structural defects, but, on the other hand, requiring less activation energy. In the author's view, when the body is heated the mean run and the mean length of the dislocation are shortened and the processes of plastic deformation degenerate at an increasing rate into amorphous bodies, where self-diffusion ensures the ductility of the body, at the time when the dislocation of finite length, becoming more marked at low temperatures, manifests itself in the form of plasticity. The book concludes with a discussion of the part played by three-dimensional flow and surface diffusion in the mechanism of sintering of metallic powders. V. L. Indenbom

Courtesy Referativnyi Zhurnal, USSR

235. Nikitina, A. K., and Bol'shanina, M. A., Influence of the velocity of deformation on the softening of copper (in Russian), (Issled. po Fiz. Tverdogo Tela), Moscow, Akad. Nauk SSSR, 1957, 146–151; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3321.

An annealed copper wire was hardened by tensioning of 26% with velocities of 0.03 and 28.5% min^{-1} and was then annealed for an hour in a vacuum at temperatures of from 150 to 350°. The stress attained by subsequent tension of 4% with a velocity of 0.3% min^{-1} was taken as the measure of the hardening remaining after annealing. Rapidly elongated samples harden more vigorously, but soften at lower temperatures; the temperature range for their intensive softening is wider (200 to 310°). The velocity of softening, more especially in samples elongated at a large velocity, is extensive in the first moments of annealing. Some conclusions are arrived at regarding the prevalence in rapidly elongated samples of unstable distortions of the lattice and the wider assortment of distortions in relation to the degree of instability.

V. M. Gol'dfarb

Courtesy Referativnyi Zhurnal, USSR

236. Polmear, I. J., The effects of copper, silver and gold on the ageing characteristics of ternary aluminum-zinc-magnesium alloys, Aero. Res. Lab., Melbourne, Austral. Rep. Met. 34, 40 pp., Feb. 1960.

237. Karpenko, G. V., The universality of the adsorption effect in the lowering of the hardness of metals (in Russian), Issl'ed. po Fiz. Tverdogo Tela, Moscow, Akad. Nauk SSSR, 1957, 273–278; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3319.

It is demonstrated that the lowering of the hardness of metals which have been subjected to the action of an external medium is explainable in each case by the penetration of elements of the medium by the adsorbing surface to the metal by ways previously opened up by defects in the structure. The stressed state of the metal makes this penetration, propagating mainly along the sliding surfaces, easier. The plastic deformation of the surface layers, on the other hand, (by rolling) produces residual stresses of compression, and, by closing up the defective voids, protects the internal spaces of the metal from penetration into them of the medium causing the lowering of hardness. N. N. Davidenkov

Courtesy Referativnyi Zhurnal, USSR

238. Novikov, A. S., and Tolstukhina, F. S., The plasto-elastic properties of rubber, brand SKN-25 (in Russian), *Kolloid. Zh.* **20,** 3, 361–369, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3380.

This is an investigation of the above rubber in the solid phase in relation to molecular weight, fractional composition, and the type of fillers used. From authors' summary

Courtesy Referativnyi Zhurnal, USSR

Structures: Simple

(See also Revs. 109, 137, 141, 145, 163)

239. Rawlings, B., An extension of the column analogy to problems in plastic analysis, *Austral. J. Appl. Sci.* **11,** 1, 80–91, Mar. 1960.

In column analogy, a third-degree statically indeterminate structure is first reduced to a statically determinate structure. The indeterminate moments m_i at a point are determined by the following

equation: $m_i = (P/A) + (M_x y/I_x) + (M_y x/I_y)$ where A, I_x, I_y are, respectively, the area, moment of inertia about principal axes xx and yy of the analogous column; x,y coordinates with respect to the principal axes; P is the angle change of the statically determinate structure; M_x and M_y are, respectively, the moments due to P about xx and yy. In plastic analysis the above equation may be written in the following form: $(M_p/\lambda) = (P/A)(1 + \alpha) + (M_x y/I_x)(1 + \beta) + (M_y x/I_y)(1 + \gamma)$ where M_p is the plastic moment at the point under consideration, λ is the load factor and α, β, λ are coefficients. The four equations for four plastic hinges in a third-degree statically indeterminate structure will give solutions to α, β, γ and (M_p/λ). Two examples are given in the paper. No rigorous mathematical proof is given. K.-H. Chu, USA

240. Sutcliffe, W. J., Limitations of the collapse method of design, *Engineer, Lond.* **209,** 5435, 514–517, Mar. 1960.

Author, who does not seem to be in favor of the plastic method of design, presents the limitations and disadvantages of the collapse method, treating its alleged advantages one by one. For this reason he examines a beam with fixed ends, which is usually applied to prove advantages of the plastic method of design. He treats in detail the contradiction also admitted by B. G. Neal, namely that according to the plastic method, the strength of the beam with fixed ends is independent of the rigidity of the end-fixation, because it is determined by plastic moment of resistance (M_{p1}) of the plastic hinge, while the strength of a simply supported beam—this being one beam of 0 per cent fixation—is only half of that of a beam with fixed ends. There are graphs to demonstrate the very large increase in the deflection of collapse as the rigidity of the fixation decreases.

Author concludes then that it is not so much that the plastic theory gives a theoretically greater strength for a beam as normally used, but that the true strength of the elastic theory is rather greater than it is normally taken to be. From this it follows that the advantage of weight-saving seems to be metaphysical. The concept of collapse seems also to be as vague, at any rate more vague than that of the yield on which the elastic method is based. The collapse of a steel-framed building is an unreal condition because local failures would occur before the structure as a whole could be loaded sufficiently to establish a collapse mechanism. This author proves with the example of a six-story framed structure, but his reasonings are not convincing enough. He also doubts that the calculations by the plastic method are easier, especially in more complicated cases. Though reviewer accepts many of the author's opinions, he doubts that this paper puts an end to the long dispute of the friends of the plastic and elastic methods over the rationality and simplicity of these two theories.

I. Koranyi, Hungary

241. Roev, V. I., Calculations for statically indeterminate systems by the method of successive approximations (in Russian), Izv. Vyssh. Uchebn. Zavedenii. Stroistvo i Arkhitekt. no. 4, 15–25, 1958; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6761.

A method is demonstrated for using successive approximations for the calculations of frames. There is some saving of time in calculating this way when compared with the Cross method—the determination of the forces at the end of the whole computation (Zeidel's iteration) as against carrying this out at each relaxation. An example is examined of the constructed diagram of the moments in the frame when its deformation is calculated while taking into account the compression forces. No comparison is given with the results of the precise calculation. N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR

242. Kuzmanovic, B. O., A criticism of the plastic-hinge concept used in the plastic theory of structures (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **19,** 147–154, 1959.

Author repeats the arguments of Hrennikoff [*Trans. ASCE* **117,** 465–470, 1952] and Stussi [*Acier-Steel-Stahl* **23,** 2, 84–90, 1958] and uses the experimental results of Stussi and of Baker [AMR **9** (1956), Rev. 3915] to emphasize the fact that collapse loads of beams as calculated by plastic limit analysis may be unconservative estimates of measured collapse loads. No mention is made of the analyses by Symonds and Neal [AMR **5**((1952), Revs. 2016 and 2361] which show that actual collapse loads of beams of the type considered by the author may be difficult to reach and recognize because of the extremely large deflections which precede the final collapse. W. E. Jahsman, USA

243. Bower, J. E., and Viest, I. M., Shear strength of restrained concrete beams without web reinforcement, *J. Amer. Concr. Inst.* **32,** 1, 73–98, July 1960.

Tests of two series of reinforced concrete beams without web reinforcement were made to investigate the behavior in shear of restrained beams. One series was designed as a study of the effects of variations in the ratio of maximum negative moment to the maximum positive moment (moment ratio). The other series was concerned with the effects of variations in the ratio of maximum moment to shear (moment-shear ratio = M/Vd).

The tests have shown that the effect of shear on the behavior of restrained beams is essentially the same as that observed for simple beams: the shear affects the load-deformation characteristics and the strength of a beam through the formation of diagonal tension cracks. The first diagonal tension crack forms at a section subjected to both moment and shear and located between the point of contraflexure and the section of maximum moment. An analysis of the test data has shown that the initial diagonal tension cracking strength is a function of the moment-shear ratio rather than of the length of the shear span.

Large variations were found in the strength beyond the initial diagonal tension cracking loads even for companion specimens. This finding supports earlier suggestions that the strength in excess of the diagonal tension cracking load is of little practical value.

Equations are presented for the initial diagonal tension cracking strength and for the shear-moment capacity.

From authors' summary

244. Holmes, M., Uniform load on a slab or plate stiffened by beams, *Struct. Engr.* **38,** 6, 196–199, June 1960.

Paper describes a method of analysis for beam and slab (or plate) systems. The theoretical analysis in its general form may be used to solve various loading conditions, but the computational work tends to be excessive. For the particular case of a uniform load over the whole area of the stiffened slab, however, the results of the analysis may be expressed as a set of coefficients the values of which may be represented graphically. For uniform loading, therefore, the method of analysis is suitable for design purposes. From author's summary

245. Brettle, H. J., The effect of variable concrete modulus of elasticity on the deflection of prestressed beams, *Austral. J. Appl. Sci.* **11,** 1, 92–107, Mar. 1960.

Author has shown elsewhere that concrete modulus of elasticity increases linearly with prestress. Based on this fact and using the elastic theory and the method of transformed section, equations are derived for the location of neutral axis, resisting moment, stresses in concrete and steel, and the deflection of prestressed beams of rectangular cross section. Theoretical deflections for beams before and after cracking have checked very well with test results from 26 beams of 4 in. by 4 in. by 10 ft.

K.-H. Chu, USA

246. Vakhurkin, V. M., Prestressing of steel constructions (in Russian), Materialyi po Stal'n Konstruktsiyam, Vol. 2, Moscow, 1958, 66–100; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3210.

The data for the prestressed constructions are divided into four groups: 1. Changes in the stressed state of the redundant systems by means of control of the magnitudes of the static frictional resistance. 2. Creation of a field of internal stresses, in a state of equilibrium without an external load. 3. Increasing the rigidity of constructions by the addition of prestressed beams. 4. Incorporation of prestressed components in the construction plan. Special attention is given to constructions in which prestressed conditions are produced by the stressing of cables, high efficiency wire or filaments. Examples are given for each group and methods of calculation are indicated. The possibility of relaxation of the initial stresses is not considered. B. M. Broude

Courtesy Referativnyi Zburnal, USSR

247. Gouda, M. A., Distribution of torsion and bending moments in connected beams and slabs, *J. Amer. Concr. Inst.* **31,** 8, 757–774, Feb. 1960.

Author solves problem of slab supported along one edge and by a beam monolithic with the slab, lying parallel to supported edge. Beam is considered elastically or rigidly built-in at its ends which lie in planes of unsupported edges. Very simplified assumption is made that each strip of slab normal to beam acts independently.

On this basis author calculates bending moments in slab and twisting moments in beam, first neglecting influence of beam deflection and later including this effect. Curves are presented for design purposes. P. C. Dunne, Brazil

248. Popov, E. P., and McCarthy, R. E., Deflection stability of frames under repeated loads, *Proc. Amer. Soc. Civ. Engrs.* **86,** EM 1 (*J. Engng. Mech. Div.*), 61–78, Jan. 1960.

Plastic design of frames frequently imposes consideration of alternated loads taking into account two typical cases: (1) The structure shakes down the plastic hinges; (2) The alternated load leads to an incremental collapse. Authors present results of three characteristic tests with simple portal frames and hinged legs applying the vertical and horizontal load in three different manners. In Test (a) proportional loading was applied basing the experimental collapse load on a deflection criterion. The tested load was higher than the calculated one. In Test (b) the vertical load is considered constant and the horizontal load is alternated. This Test is characteristic for proving the "shake down" theorem, obtaining a very good accordance to the refined analysis. In Test (c) the incremental collapse load caused by alternated horizontal loads was found considerably higher than the computed one.

Authors underline importance of further tests to obtain basic knowledge for correct plastic design of structural frames for wind and earthquake loading. Reviewer points out that the confirmation by tests of the "shake down" and "incremental collapse" theorems is very important to dispel some serious doubts, especially in European countries, over the justification of plastic design to frames stressed with alternated load. Further tests to state fatigue life of such frames are necessary too. H. Beer, Austria

249. Filimonov, M. A., Problem regarding calculations for a deformed frame (in Russian), *Trudi Novocherk. Politekhn. In-ta* **78/92,** 67–76, 1958; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6760.

By using comparative calculations in accordance with the method of transpositions an investigation is carried out on the influence of longitudinal deformations on the magnitude of the deflection moments in the rods of symmetrical π-shaped restricted frames with rigidly fastened and hinge-supported constructions, when symmetrically disposed concentrated vertical forces are acting on the cross bar of the frame. It was established that disregard of the longitudinal deformations may lead to considerable error either by magnification or by reduction of the calculated deflection moments in dependence on the relation of the magnitudes of the external forces to the Euler longitudinal forces in the cross bars, to the relative disposition of the external forces and also to the exponent of the flexibility of the cross bars. Supplementary graphs are provided for the calculation of similar frames which take into account the influence of longitudinal deformations. Numerical examples are given. A. F. Anishchenko

Courtesy Referativnyi Zburnal, USSR

250. Fanelli, E., New method for the solution of two-dimensional elastic frames (in Italian), Cons. Naz. Ricer. no. 510, 9 pp., 1957.

A solution is presented, based on the method of deformation, restricted to treatment of multi-storey, multi-bay plane frames, with vertical and horizontal members; similar to Takabaya's procedure [F. Takabaya, "Rahmenformeln," Springer-Verlag, Berlin, 1930]. However, by expressing in a preliminary stage the angle of sideway of each storey in terms of the unknown angles of rotation of the adjacent joints, author reduces the number of equations to be solved to the number of elastically rotating joints. In the example given, system of equations is solved by iteration.

A. Werfel, Israel

251. Kirkland, G. W., Tall buildings—problems in the design and construction as affecting the structural engineer, *Struct. Engr.* **38,** 6, 177–184, June 1960.

252. Jacquemin, R., Method of calculating stresses and displacements in pipelines under thermal expansion (in French), *Rev. Tijdschr.-Mecan. Werk.* **4,** 4, 250–258, 1958.

Author explains how to analyze single- and multibranched piping systems, with additional constraints (if present), mostly from the viewpoint of using a desk calculator. Usual formulas for the calculation of piping-section influence coefficients are not tabulated, but their calculation is outlined and their transfer from point to point is detailed. Practical suggestions for numerical work are given. Reviewer feels that the subject matter has been more proficiently and exhaustively treated in well-known earlier references, apparently unknown to author, such as AMR **6**(1953), Rev. 2765 (and subsequent discussions in the same Journal), AMR **9** (1956), Revs. 1765, 1766, 1767. J. L. Lubkin, USA

253. Rosenblueth, E., A live load theory for buildings (in Spanish), *Ingenieria* **29,** 4, 51–72, Oct. 1959.

Author makes statistical study of live load in buildings, emphasizing the differences in building codes in specifying live load reductions only as function of the number of stories. These specifications are on the safe side, but occasionally on the unsafe side. More rational results could be obtained if live loads were reduced as a function of the influence area. A probability approach to the few experimental data led the author to the formula

$$w_F = \overline{w} + cf\overline{w}A^{-\frac{1}{2}}$$

where w_F is the design live load per unit of area produced by a generalized force F having a specified probability of failure; c depends on the shape of the influence surface; f and $\overline{w}$ on the probability of failure and on the use of the area; and A is the loaded area. If A is the tributary area in the usual sense, author found c ranges from 0.88 to 1.23, and advises to adopt 1.2. Then it is a simple matter to specify $f\overline{w}$ for different types of structures or members. It would be premature to give specific values before taking a large number of actual measurements of live load. Author mentions that problems of live load for settlements and accidental loads could be treated in the same probabilistic manner.

R. Diaz de Cossio, Mexico

254. Nikolaev, K. I., The application of B. B. Golitsyn's problem for the calculations of large installations in relation to the action of seismic forces (in Russian), *Trudi In-ta Antiseismich. Str-va Akad. Nauk TurkSSR* **2,** 3–44, 1958; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6835.

The variational principle evolved by Hamilton-Ostrogradskii is applied when deriving the equations of motion. An investigation is carried out on the conditions governing seismic stability of massive constructions on elastic foundations with arbitrary motion of the foundations (models of the elastic foundation are utilized: in the sense of a hypothesis of the coefficient of a bed, elastically inertional and in an elastic semi-space). A number of numerical examples are solved to clarify the parts played by various factors: the dimensions and the volumetric weight of the constructions, the pliability of the foundation, the external load. The results obtained are tabulated and are also given in the form of graphs.

B. K. Karapetyan

Courtesy Referativnyi Zhurnal, USSR

255. Nazarov, A. G., On the theory of the mechanical similarity of solid bodies and its application to the investigation of building constructions and the seismic stability of the constructions, Communication 1 (in Russian), *Izv. Akad. Nauk ArmSSR. Ser. Tekhn. Nauk* **10**, 5, 15–28, 1957; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6836.

A more detailed account is now furnished for a method previously put forward by the author for the investigation of similarity in the processes of deformation of solid bodies[*Dokladl Akad. Nauk, SSSR (N.S.)* **25**, 3, 101–106, 1957]. The results are recorded in the form of "a fundamental theorem" and ten consequential effects. Examples are examined emanating from the theory of elasticity. The results of the study are obtained simply by using an analysis of dimensions (the Π-theorem). The possibility of introducing independent dimensions for the undeformed dimensions of bodies and of transpositions, which are actually made use of by the author (for this is the basis of his special determination of the "expanded similarity of bodies"), can be utilized for small transpositions, that is, it appears to be an approximation and is determinable by a special structural linkage between the stresses and the deformations. Therefore the resulting consequential effects for similarity and modelling are easily attained in the investigation of the equations of the problem by the aid of the methods of analysis of the dimensions following the procedure employed in the theory of the boundary layer in transonic and hypersonic gas dynamics.

S. S. Grigoryan

Courtesy Referativnyi Zhurnal, USSR

256. Bukhvostov, N. V., An analysis of the deformation of bodies in earthquakes, based on modern methods of calculations for building constructions in regard to their seismic stability (in Russian), *Byul. Soveta po Seismol., Akad. Nauk SSSR* no. 3, 137–150, 1957; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6838.

An analysis is given of the damage done to buildings in the Ashkhabadsk earthquake in 1948, compiled from the point of view of current methods for the determination of seismic forces. To carry this out a selection was made of two groups of two-storied residential houses of simple outline and a clear-cut constructional design. Two cases were examined: (1) destruction of the walls because of deformations in the plane of the wall; (2) destruction of the walls because of deformations outside the plane of the wall. As the result of the analysis of the damage done to these buildings the author comes to the conclusion that the methods investigated for making the calculations appear to be conditional and have a limited field of application.

B. K. Karapetyan

Courtesy Referativnyi Zhurnal, USSR

257. Khachiyan, E. E., The seismic stability of structures of stepped outline with increases in height (in Russian), *Dokladl Akad. Nauk ArmSSR* **26**, 5, 269–275, 1958; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6841.

An investigation is carried out of the horizontal shear vibrations of a beam possessing a stepped outline by height, a scheme which corresponds approximately to a building with a light superstructure or to a building with a base made of a more rigid material. Numerical examples are given for two cases, when the upper or the lower step comprises ¼ of the general height; to simplify matters it is assumed that the beam has been manufactured from a single material, while the relation of the areas of the transverse sections of the steps is taken to be equal to 4. The increase is noted, in both cases, of the tangential stresses in the upper portions of the beam. The results obtained correspond with the observations on the destruction of the upper portions of constructions in heavy earthquakes.

B. K. Karapetyan

Courtesy Referativnyi Zhurnal, USSR

258. Kalmanov, A. S., Practical methods for the calculations for multi-storied buildings under the action of horizontal loads (in Russian), Questions concerning the calculations for the construction of residential and public buildings with prefabricated parts, Moscow, Gosstroiizdat, 1958; *Ref. Zh. Mekh.* no. 6, 1959, Rev. 6843.

An approximate solution is given for the wall beams of great height which constitute the framework components of the building; this is effected by means of a stress function selected from the conditions for the minimum potential energy of the wall's deformation; a computation is also made for the elastic resistance of the foundation to compression and shear. When taking the openings in the walls (diaphragms) into consideration it is assumed that the wall, weakened regularly by the orifices, consists of a series of vertical bars (pilasters) linked up in a system of continuous ties, the shear resistance of which varies in accordance with the linear principle, increasing with proximity to the foundation of the building. Arising from the condition of minimum energy a value is found for the reaction of the ties, moments and longitudinal forces in the pilasters which agrees satisfactorily with the exact solutions. An examination is also made of the approximate solution for a multi-storied framework, the following proposition, already known in the literature, being applied: the framework is substituted by a single-span portal, subjected to the action of a horizontal nodal load; the stiffness of the cross bars of the portal is equal to the sum of the stiffness of the cross bars of the frame of a given story; the stiffness of the bracing = to the half sum of the stiffness of the bracing of the frame. The method of forces is used; the system of equations is solved by means of the method of finite differences. Calculations are investigated in their general form of ten-storied portals and a system is computed in its numerical form of a portal with a linkage in the form of an equivalent cantilever beam replacing the diaphragm.

I. K. Snitko

Courtesy Referativnyi Zhurnal, USSR

259. Mead, D. J., The internal damping due to structural joints and techniques for general damping measurement, Aero. Res. Counc. Lond. Curr. Pap. 452, 41 pp., 1959.

Various methods are considered for the determination of structural damping in simple riveted or bolted joints. Beams, consisting of hollow extrusions with rectangular cross section and with simple joints in the bending flanges, were used to test three of the methods: (1) static load-deflection measurements giving the hysteretic damping in one loading cycle; (2) measurement of the energy-input per cycle with force and velocity transducers at the resonant frequencies of the beams; (3) measurement of the free oscillation decay at the resonant frequencies. In this sequence the methods gave successively lower values for the energy-loss per cycle. The dependence on frequency and amplitude was established. The influence of the supports (bungees) may have been appreciable.

M. Botman, Canada

Structures: Composite

(See also Revs. 75, 81, 82, 123, 146, 222, 223, 240, 253, 382)

260. Dehousse, N. M., On the methods of calculation of thin walled, arch dams: Study of the influence of hydrostatic and thermal effects (in French), *Ann. Trav. Publ. Belgique* **4**, 325–357, Aug. 1959/60.

Author reviews the different methods of analysis for thin arched dams, discussing the membrane analysis solution, the multiple horizontal arches approach, the arch wall-strip grid approach, and, finally, Lombardi's and Naimi's work using the relaxation method.

For the analysis of thermal effects, author discusses Stucky's and Derron's methods. J. G. Bouwkamp, USA

261. Wendel, K., The probability of surviving damages (in German) *Schiffstechnik* **7**, 36, 47–61, Apr. 1960.

Problem of subdivision of a ship by bulkheads is solved as a definite integral which expresses the probability that the ship will not sink if one or more compartments are damaged. Examples are demonstrated for three real ships: a passenger liner, a cargo ship, and a small coaster. S. Kolupaila, USA

262. Brock, J. S., Investigation of keel block loads during dry-docking of USS Rowan (DD 782), David W. Taylor Mod. Basin Rep. 1299, 29 pp., July 1959.

An experimental study of the keel block loads of a dry-docked destroyer are reported in some detail. Daily variations due to changing ambient temperatures are included. Also included is a comparison with an approximate solution, based on the analysis of a beam on elastic foundations, for the maximum reactions near the end blocks. A comparison with a more exact analysis of the beam on elastic foundation which has an energy solution of the differential equations is also included. A useful table of 20 subdivisions in the beam length for properties of the free-free beam vibration modes used in the expansion is included.

J. E. Duberg, USA

263. Klitchieff, J. M., Computation of deck structures in naval architecture (in Serbian), *Classe Sci. Tech. Acad. Serbe Sci.* **237**, 4, 91–139, 1959.

Machine Elements and Machine Design

(See also Revs. 25, 26, 94, 297, 578, 581)

264. Hirschhorn, J., Dynamic acceleration analysis, *Mach. Design* **32**, 4, 151–155, Feb. 1960.

Author solves problem of the motion of a linkage assuming only that the forces acting on one or more parts of the linkage are known. This problem has been previously solved utilizing an energy method, but graphical constructions were required. Author utilizes the acceleration relations developed by Goodman to make the energy balance procedure entirely analytic.

W. J. Carter, USA

265. Lakhtin, A. A., The analysis of some machine elements with toroidal parts (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **26**, 66–77, 1958.

The approximate power series solution of the differential equation, in complex form, of a toroidal shell, due to Novozhilov ["Theory of thin shells," Moscow, 1951] is given. Corresponding numerical data for various cases of loading and geometrical characteristics of shells are thoroughly tabulated, which may prove very useful in the design of such machine elements as syphons, compensators, etc.

D. Radenkovic, Yugoslavia

266. Second All-Union conference on the fundamental problems in the theory of mechanisms and machines [Hoghi vtorogo vsesoiuznojo soveschania po osnovnym problemam teorii mashin i mekhanismov] Moscow, Akademia Nauk SSSR, Institut Mashinovedenia, 1958, 51 pp. + bibliography.

Volume presents the works of the opening session of the conference, the reports of the five sections and the resolutions of the closing session.

In the preface I. I. Artobolevski, member of the U.S.S.R. Science Academy, and A. P. Bessonov point out that at the first conference, which took place in 1954, main directions were established in view of developing the theory of mechanisms and machines. Authors emphasize the results obtained since 1954, underlining especially the realizations in the field of constructing automatic machines, automatic lines, automatic factories, and so on.

After showing the aims of this conference, authors review the reports presented at the conference.

L. P. Bardin, deputy-president of the U.S.S.R. Science Academy, referred to problems of automation and mechanization of production.

A. A. Blagonravov, member of Academy and director of the Institute for the study of machines, discussed the theory of machines in conjunction with automation problems in industrial processes.

N. G. Bruievich, member of Academy, analyzed the main trends of the science of accuracy in machine construction, mentioning meanwhile the more important achievements.

Further, the reports of a general character presented by foreign delegates are reviewed.

I. I. Artobolevski states in the report: "Present state of the theory of mechanisms and machines" is the task of the 1958 conference, namely a retrospective view of the results obtained by Soviet and foreign scientists in the theory of mechanisms and machines throughout the period between the two conferences (1954–1958). After a survey of the great achievements of Soviet science and technique and achievements in the construction of automatic machines, he outlines accomplishments in the field of the theory of mechanisms and machines during the above-mentioned period. Author describes the continuous development of this discipline as a sequence of certain problems raised at the first conference, such as: kinematic analysis and synthesis and dynamics of plane and spatial mechanisms with lower and higher pairs, development of the geometry and synthesis of toothed wheel gearings, theory of mechanisms with flexible members, pneumatic and hydraulic devices as part of mechanisms, dynamics of machines and mechanisms.

After mentioning a series of studies, published both in U.S.S.R. and abroad, author shows the way in which the general methods of the theory of mechanisms and machines were reflected in the formation of a new scientific branch called theory of automatic machines. Works showing the relation between the theory of automatic machines are then reviewed and the courses and textbooks published between the two conferences for students and engineers working in the field are presented.

The synthesis reports presented by the chairmen of the five sections—The analysis and synthesis of mechanisms, Machine dynamics, Theory of accuracy in machine and apparatus construction, Theory of automatic machines, Theory of machine drives—gave figures concerning the number of sessions held within each section, stressed the contribution brought by the speakers and underlined the directions along which the research work was carried out.

Prof. N. J. Levitski, summarizing the 16 reports and 7 scientific notes presented at the section for the analysis and synthesis of mechanisms, emphasized the resulting new aspects. In the analysis of mechanisms, new methods were proposed connected to the mathematical apparatus which previously was less frequently used. The helicoidal calculation was applied in the analysis of spatial mechanisms with lower and higher pairs. The matrix method, which corresponds to the solving of many analytic

problems and partially to synthesis problems, was successfully applied in various papers. The use of other methods in the analysis of mechanisms suggested new applications for mechanisms.

Levitski quotes papers on the synthesis of mechanisms and discusses the paper presented by I. I. Artobolevski who proposed several methods for the formation of mechanisms theoretically accurate for reproducing algebraic and transcendental curves. By using these methods, a series of new mechanisms may be obtained for reproducing a large class of functions.

Prof. W. Lichtenheldt's paper (German Democratic Republic) on the synthesis of rectilinear sliding mechanisms is then quoted. The paper based on the use of design kinematic schemes, giving the most adequate criteria, solves also certain problems pertaining to the synthesis of six- and eight-bar mechanisms by using geometrical methods.

Another example of combining geometrical and analytical methods is included in Levitski's paper. There, the analytical method completes the geometrical methods for the design of six-bar mechanisms. Using this method, a six-bar transmission mechanism can be designed with the help of seven parameters, obtaining thereby a linkage with arrests of a given duration and reproducing at the same time a given law of motion on the working portion of the stroke.

A. E. Kobrinski's report emphasizes the basic problems around which the ten papers and twelve scientific notes were grouped, namely: Investigation of the vibration processes in machines; Problems of kinetostatics and dynamics of machine aggregates; Development of general experimental methods and their results with application to various machines.

Of the papers presented several were based on the research carried out in the dynamic strength laboratory of the Institute for the study of machines. These dealt with problems pertaining to the resonance properties of the centrifugal vibrator, resonance regimes of unbalanced rotor motion, resonance processes in complex machine systems, details of unsteady vibration processes.

Other papers included investigations of the self-synchronization of vibrations, analysis of free vibrations of machine foundations placed on nonlinear springs with parabolic elastic characteristics, free and forced vibrations of systems under impact, vibrations and problems connected to their dynamic stability.

Concluding the section on the theory of accuracy in machine and apparatus construction, G. G. Baranov analyzes briefly each paper underlining the problems approached within this section, namely: Increasing the accuracy of various devices by correctly choosing tolerances in the control methods; The synthesis and analysis of complex devices which ensure a given accuracy; Dynamic accuracy of mechanic and electronic circuits and operating accuracy of electronic computers; Errors in toothed gearing as a source of vibration and noise in the turbine reduction gears; Manufacturing errors in ball and roller bearings constructed in automatic lines.

S. I. Artobolevski presents a comprehensive analysis of reports delivered within the section for the theory of automatic machines, showing that modern and important problems were approached, such, as: structure of automatic technologic machines and its part in the development of the general theory of these machines; theory of productivity of working machines and aggregates for the automation of industrial processes; dynamics of programmed control systems; problems concerning the productivity of machines, and so on.

The last report is by V. I. Gavrilenko, chairman of the section for the theory of machine drives.

Volume also includes the resolution of the closing session of the conference, mentioning that in the period between the two conferences, a series of important research works were carried out in the main branches of the theory of mechanisms and machines according to the directives arising from the first conference. After analyzing the most valuable results obtained in the above problems, the resolution indicates the lines along which future studies and investigation are to be carried out.

D. Mangeron and R. Bogdan, Roumania

267. Artobolevskii, I. I., Some new types of mechanisms for the production of plane curves (in Russian), *Trudi In-ta Mashinoved. Akad. Nauk SSSR; Seminar po Teorii Mashin i Mekhanizmov* **16,** 64, 54–64, 1957; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4721.

The construction is given of a number of mechanisms for the production of plane curves: (1) a mechanism for the simultaneous delineation of two ellipses in which the lengths of the half-axes a_1, b_1 and a_2, b_2, the eccentricities e_1 and e_2 and the distances c_1 and c_2 of the foci of the ellipses from the center common to them all are linked with the conditions $e_1 = e_2$, $\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$; (2) a mechanism which delineates a parabola and at the same time bends round it; (3) three different mechanisms for the delineation of a cardioid; (4) a mechanism for the delineation of a cardioid which simultaneously bends around it; (5) a mechanism for the delineation of a three petal rose; (6) a mechanism for the delineation of a four-petal rose; (7) a mechanism for bending around a tri-apical hypocycloid; and (8) a mechanism for the delineation of "Dioklesa" cissoids.

S. A. Cheskudinov

Courtesy Referativnyi Zhurnal, USSR

268. Malyarova, V. M., The dynamics of cam gears (in Russian), *Trudi Sibirsk. Metallurg. In-ta*, 4A (Prikl. Mat. Mekh.), 1957, 139–153; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4728.

A method is described for the dynamic investigation of the cam gear mechanisms of high-speed automatic machines. On the basis of the investigation a presentation is submitted of the changes in the moments of the forces of elasticity in torsional oscillations and conditions are formulated which cause the regime of work of high-speed cam gear mechanisms to approach the static.

V. A. Zinov'ev

Courtesy Referativnyi Zhurnal, USSR

269. Veretakov, G. V., A new technical method for the calculations of the shells of winding drums of mineshaft lifting equipment (in Russian), *Zap. Leningrad Gorn. In-ta* **33,** 3, 117–131, 1956; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2913.

The approximate method given in the title is described; the shells are fastened at the ends and are subjected to the pressure of the cables wound on the drums. The proposed method is based on the theory of the deflection of a round cylindrical shell, symmetrically loaded relative to its axis. The calculation load is taken to be the specific pressure when one, two or more coils of cable are wound on the drum with an approximate evaluation for the deflection of the shell determined from formulas obtained by other authors. Cases are examined of evenly distributed loading due to the cable's pressure over the whole length or portions of the length of the shell. The method provides for the calculation of the shell of the drum both as regards strength, starting from the hypothesis of strength, and as regards stability starting from Sawtell's formula and its development by P. F. Pankovich [see "Studies on the strength of ships," Leningrad, Sudpromgiz, 1956, 680 pp]. Tables and graphs of supplementary functions and parameters taking part in the formulas and depending on the dimensions of the shells are provided. The article contains a large number of printer's errors, some of them in the calculation formulas.

V. V. Novitskii

Courtesy Referativnyi Zhurnal, USSR

270. Kol'zon, A. S., The dynamics of a rigid motor rotating between two elastic supports (in Russian), *Ucb. Zap. Leningrad Vyssb. Inzb. Morsk. Ucbsbcbe* no. 10, 41–60, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2979.

It is shown that in the case of a vertically laid out rotor with five steps of freedom (the axial displacement being eliminated through a bearing), if the increase of angular velocity of the statically and dynamically unbalanced rotor is not controlled and the supports are elastic, both states of unbalance tend to reach zero value (self-centering). A method of calculation is described for the characteristics of the elastic supports enabling the radial dynamic reactions on the supports to be brought down to zero for any assigned velocity. There remain as possibilities vibrations due to resonance produced by other exciting periodic forces (not by static or dynamic unbalance). V. K. Zhitomirskii

Courtesy Referativnyi Zhurnal, USSR

271. Bogdan, R., Pelecudi, C., Calmaciuc, L., and Antonescu, G., A polar transcriber for investigating linkages (in German), *Rev. Mêcan. Appl.* **5**, 1, 67–79, 1960.

Fastening and Joining Methods

(See Revs. 192, 259)

Rheology

(See also Revs. 90, 91, 414)

272. Segawa, W., Rheological equation of Voigtian material, *J. Phys. Soc. Japan* **14**, 8, 1102–1106, Aug. 1959.

Author obtained the three-dimensional extension of rheological equation of state for large deformation of a Voigt material, generalizing in this way Rivlin's equation of the finite elastic deformation and Reiner-Rivlin's equation of isotropic viscous liquid. The theory uses Lagrange and Euler representations explicitly. Important remarks are deduced applying this general equation to simple elongation and simple shear.

M. J. Predeleanu, Roumania

273. Emersleben, O., Parallel flow of viscous fluids between coaxial cylinders in the limiting case when the inner tube vanishes (in German), *ZAMM* **38**, 11/12, 466–472, Nov./Dec. 1958.

The, in some respects, singular Hagen-Poiseuille limit of laminar flow between two coaxial cylinders when the radius of the inner one tends to zero is discussed in a detailed manner.

F. Engelmann, France

Hydraulics

(See also Revs. 30, 64, 361, 366, 376, 377, 383, 539, 540, 559, 573, 576)

274. Haque, S. M. A., The effect of eddy viscosity on the velocity profile of steady flow in a uniform rough channel, *J. Fluid Mech.* **5**, 2, 310–316, Feb. 1959.

Author establishes the equation of motion for the steady flow under gravity of a liquid in a uniform channel, including the effects of the friction of the bed and of the eddy viscosity for lateral mixing. The solution of this equation is furnished and the distribution of mean velocity across the channel is found when: (a) the cross section is rectangular and infinitely wide with constant eddy viscosity; (b) the cross section is rectangular of finite width with constant eddy viscosity; (c) the cross section is rectangular and infinitely wide with eddy viscosity varying linearly with depth and mean velocity; (d) the cross section is rectangular of finite width with eddy viscosity varying linearly with depth and mean velocity; (e) the cross section is triangular; and (f) the cross section is trapezoidal. A numerical estimation of the effect of eddy viscosity on different velocity profiles shows that the effects of eddy viscosity are important in regions where depth is changing and in narrow channels. L. J. Tison, Belgium

275. Ellison, T. H., A note on the velocity profile and longitudinal mixing in a broad open channel, *J. Fluid Mech.* **8**, 1, 33–40, May 1960.

Case of flow in an open channel is considered disregarding the effects of secondary flows and interaction with the air flow above the surface. Similarity conditions at the free surface are considered and a new empirical constant m is introduced analagous to k in the eddy diffusion equation for flow near a rigid boundary. Solution for the velocity distribution shows that it is only mildly affected by m. However, analysis of the longitudinal diffusion coefficient indicates that m should be determinable from measurements of diffusion. Author concludes with an approximate analysis of the correction required for finite Reynolds number.

W. D. Baines, Canada

276. Hocking, L. M., and Michael, D. H., The stability of a column of rotating liquid, *Mathematika* **6**, 11, 25–32, June 1959.

A study is made of the effects of rotation on the stability of a liquid column having a free surface. In the rotational motions considered, there are two sources of instability, one arising from the rotation of the fluid, and the other from the shear across the interface separating regions of different angular velocities. It is found that the surface tension which is able to counteract the first is unable to stabilize the disturbances arising from the shear across the interface. A. H. Sacks, USA

277. Perzhnyanko, E. A., The problem of the wave resistance of a body moving in a circle, *Soviet Phys.-Doklady* **5**, 1, 43–45, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130**, 3, 514–516, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

Let an arbitrary rigid body be moving horizontally in a circular path with constant angular velocity ω, under the free surface of an ideal heavy liquid of infinite depth. We consider the cases of the motion of the body in a circular basin, in a circular channel, and outside a circular cylinder. The last case also includes the motion of a body in an unbounded liquid with a free surface. The problem is solved in its linear statement. It is also assumed that the motion of the body has been going on for an infinite time, so that, in axes connected with the body, the velocity potential of the liquid is stationary. From author's summary

278. Ripken, J. F., and Killen, J. M., A study of the influence of gas nuclei on scale effects and acoustic noise for incipient cavitation in a water tunnel, Univ. Minn., St. Anthony Falls Hydraulic Lab. Tech. Pap. no. 27, Series B, 49 pp., Sept. 1959.

This is a continuation of Project Report no. 58 of the same laboratory by the first author, with its appendix by R. M. Olson for the sonic method of measuring the concentration of undissolved gas nuclei in water. Incipient cavitation experiments were conducted in a modified air-separator-type recirculating closed water tunnel at velocities 20 to 50 fps in the 6-in. test section with various controllable total dissolved and free gas (nuclei) contents, mostly with 1.5 caliber ogives of 0.625-in. diam, some with 0.75-in. and 0.542-in. diam for scale effect. Authors' qualitative conclusions state that the Thoma cavitation index (σ) depends largely on the size and number of the nuclei, and these on the tunnel circuit, stabilization time, maximum pressure, resorber or lack of it, besides turbulence and acoustic shock waves.

The number and size of the nuclei are susceptible to measurement by frequency analysis of the attenuation of acoustic noise in water, which latter was pretty well measured at 25 fps but did not check at 40 fps.

The differences between model tests in various tunnels with their water, besides the arbitrary definition of incipience of cavitation by the first visual streak of 1/8-in. length, make the σ values obtained a rough approximation for prototypes in media with different free gas content with changed time rates, travel, etc., even with some modifying formulas.

When all these factors are considered, the task to get closer σ values is formidable. A. Hollander, USA

279. Pogosyan, M. G., Hydraulic resistance of two-phase liquid flow in horizontal pipes under pressure (in Russian), *Gidrotekh. Stroit.* **27**, 2, 39–42, Feb. 1958.

Experimental results are given by graphs for flow of water and water-plus-sand mixtures. Pipe diameters were 50, 75, 105 and 150 mm with various relative roughness as indicated by constant friction magnitudes with pure water for higher *Re* range. With solid-to-liquid ratios of 5 to 40%, three flow regimes were implied by the character of the curves, with the conclusion that for the high *Re* values (important for "hydrotransport") the solid particles merely raised the friction factor by increments proportional to the solid-to-liquid ratio. Mean grain diameter for all experiments was 0.27 mm. A. G. Fabula, USA

Incompressible Flow

(See also Revs. 63, 273, 276, 297, 328, 329, 346, 349, 361, 366, 369, 380, 424, 458, 467, 511, 535, 538, 540, 541, 542, 563, 572)

280. Donnelly, R. J., and Simon, N. J., An empirical torque relation for supercritical flow between rotating cylinders, *J. Fluid Mech.* **7**, 3, 401–418, Mar. 1960.

Experimental data by Wendt, Taylor, and Donnelly for various gap-radius ratios are compared in terms of torque versus speed. In all cases inner cylinder is at rest. Torque/laminar torque differs from unity by a contribution from secondary flow. Latter is assumed to include two terms, which vary like Ω^{-2} and like $\Omega^{0.36}$ respectively and which cancel at the critical speed. Effect of gap-radius ratio is also studied for speeds far above critical speed by similar method. Reviewer believes that authors' empirical formulas are suited only for experiments considered, but that Batchelor's analysis (appendix of present paper) should have useful applications to more general cases such as the case of both cylinders rotating. D. Coles, USA

281. Hacques, G., Application of the electrolytic analogy to the problem of ring airfoils (in French), Publ. Scient. Tech. Air, France no. 358, 122 pp., 1960.

A number of flow problems concerning ring wings at low speeds are solved by aid of the electrolytic tank. The principle of the method is to identify the velocity potential with an electric potential in a conductor. The gradient of the velocity potential is then proportional to the electric current.

In the first chapter the distribution of the angle of attack of a system, consisting of a ring wing with two semi-elliptic plane wings attached to it, is determined using the Trefftz plane. This system should have minimal induced drag on the basis of Prandtl's lifting-line theory. Also, for arbitrary systems the distribution of the circulation is determined.

The second chapter deals, for axial flow, with the effects of conicity, camber and thickness and the effect of a central body. Pressure distributions are determined. In the third chapter the boundary-value problem for an infinitely thin circular cylinder under angle of attack (lifting-surface theory) is solved electrolytically. Results agree with those obtained by Weissinger.

In chapter four a propeller is placed in a cylindrical ring wing. The case when the circulation around the propeller is constant along its length is considered in more detail. It is assumed that the propeller plane forms a discontinuity in pressure. The pressures at inner and outer sides of the ring wing are determined from the measurements.

In the last chapter the streamlines for axial flow are obtained by aid of a tank of which the bottom has a partly hyperbolic form. In this case the stream function is identified with the electric potential.

In all chapters applications of the reverse flow theorem are given.

The whole investigation shows beautifully the power of the electrolytic analogy. A. I. van de Vooren, Holland

282. Beyer, R. T., Parameter of nonlinearity in fluids, *J. Acoust. Soc. Amer.* **32**, 6, 719–721, June 1960.

Values of the parameter of nonlinearity for acoustics $B/A = (\rho_o/c_o^2)(\partial^2 p/\partial \rho^2)_s$ are given for all liquids for which experimental data are available. The experimental data indicate that B/A generally increases slowly with temperature. A method of computing B/A directly from finite-amplitude acoustic measurements is also presented. From author's summary

283. Diprima, R. C., The stability of viscous flow between rotating concentric cylinders with a pressure gradient acting round the cylinders, *J. Fluid Mech.* **6**, 3, 462–468, Oct. 1959.

The stability of a viscous fluid flowing in the thin annulus between concentric cylinders is analyzed for the case in which the cylinders are differentially rotated and, at the same time, the fluid is "pumped" through the annulus by a pressure gradient. Numerical results for the critical value of the parameter governing stability are presented for a large range of ratios between the pumping and rotational velocities for the case in which the outer cylinder does not rotate. Comparisons made with experimental data obtained by Brewster, et al [AMR **13**(1960), Rev. 2348] show good agreement. J. M. Hedgepeth, USA

284. Hocking, L. M., The Oseen flow past a circular disk, *Quart. J. Mech. Appl. Math.* **12**, 4, 464–475, 1959.

Oseen problem for disk normal to infinite stream is treated by constructing integral equations for "doublet" and "quadrupole" distributions on disk. For small Reynolds numbers (R), drag is found correct to $0(R^3)$, agreeing to $0(R)$ with Oseen's result [Hydrodynamik," Leipzig, p. 205, 1927], and existence of reversed flow on axis of symmetry is noted. Solution is also derived for R large. W. W. Wood, Australia

285. Rogozhin, V. S., Finding the shape of a body from a given impact pressure, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23**, 3, 834–838, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

Paper discusses the inverse hydrodynamic impact problem, i.e., it determines the shape of the impacting body in contact with the liquid if the pressure distribution is given. Technique is applicable to the two-dimensional, incompressible, linearized case when $\phi\rho = -p_t$, i.e., the velocity potential (ϕ) is linearly connected with the impulse pressure (p_t), which condition is valid for a short duration immediately after impact. Several special cases are solved applicable to families of body contours.

V. G. Szebehely, USA

286. Borisenko, A. I., and Myshkis, A. D., Temperature and velocity distributions in a laminar flow of a fluid between rotating coaxial cylinders, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23**, 4, 1054–1065, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

With rotating machinery in mind, the title problem is specialized to the case of incompressible fluid with a stationary outer (subscript 2) cylinder, i.e. tangential velocity $W_2 = 0$. The lateral balance between heat conduction (variable coefficient $\lambda(T)$) and

viscous dissipation (variable coefficient $\mu(t)$) is characterized by a dimensionless number $K = W_1^2\mu_2/(T_1 - T_2)\lambda_2$, where T is the temperature. First, iteration procedures utilizing expansion in powers of K are explored, including estimates of errors. Secondly, for the case of slowly varying $\lambda(T)$ and $\mu(T)$, perturbation procedures in the variations are carried out to second order, again with a discussion of errors. M. V. Morkovin, USA

287. Ter-Krikorov, A. M., The nonlinear problem of the theory of a submerged airfoil, *Soviet Phys.–Doklady* **3,** 2, 255–258, Dec. 1958. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **119,** 6, 1115–1117, Mar.–Apr. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The airfoil, of indefinite breadth, submerged beneath the free surface of an ideal incompressible dense fluid of finite depth, is assumed in steady motion. The problem is to find, for the reversed motion of the fluid (with constant velocity at infinity), the complex velocity potential consistent with all boundary conditions.

By conformal mapping, the flow around the submerged airfoil is converted into a flow around a different contour within a straight tube. The problem of going back to the first contour is solved by a method of inversion. The author uses a set of nonlinear integral equations, a linear and a nonlinear operator, and obtains the solution in most cases with a good approximation.

R. Spronck, Belgium

288. Dean, W. R., An application in hydrodynamics of Green's function of an elastic plate (in English), *Mathematika* **5,** 10, 85–92, Dec. 1958.

Paper is based on the similarity between the equations governing steady two-dimensional incompressible viscous flow and the static lateral deflection of plates: the stream function is analogous to the deflection, the inertia terms are analogous to the lateral loading, and the body contour is replaced by a clamped boundary. Author uses the analogy to clarify the nonexistence of a solution for the slow (no inertia terms) steady streaming of liquid past a fixed body. He then incorporates some effects of inertia terms approximately by introducing Green's functions for the plate and shows that "non-slow" flows are possible. The flow about a circular cylinder is treated in particular and deductions about the character of the flow are made. J. M. Hedgepeth, USA

289. Kuznetsov, A. V., The flow about a curvilinear arc with a discontinuity in the current (in Russian), *Uch. Zap. Kazansk. Inta* **117,** 9, 95–99, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2577.

An investigation is made of an unbounded potential flow of an incompressible liquid, flowing about a curvilinear arc, disposed symmetrically in relation to the direction of the velocity at infinity, the current being interrupted in places. An approximate method of solution is proposed based on somewhat general assumptions concerning the form of the arc. Compared with the results of investigations by A. I. Nekrasov, Ya. I. Sekerzhzen'kovich, M. A. Lavrent'ev, P. B. Myasnikov, G. N. Pykhteev and others the proposed method is different in that the arc being investigated is supported by a given chord, and the ends of the arc appear to be points of discontinuity in the current; at the same time the assumption is made that the change in the curvature in the transition from the contour to the free current goes on continuously and that the straight lines parallel to the undisturbed flow intersect the contour being flown about at only one point.

S. V. Kalinin

Courtesy Referativnyi Zhurnal, USSR

290. Lachmann, G. V., Aspects of insect contamination in relation to laminar flow aircraft, Aero. Res. Counc. Lond. Curr. Pap. 484, 24 pp., 1960.

291. Evdokimov, Yu. A., The problem of choice of pressure and expenditure of air in an atmospheric screen in relation to its construction (in Russian), *Trudi Rostovsk. In-ta Inzh. Zh.-d. Transp.* no. 24, 308–326, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4888.

The paper reviews the theoretical and experimental studies carried out to investigate air screens. An extensive series of experiments with screens of different types was carried out in order to select the optimum parameters of an air screen. Apparatus used in the experiments is described in detail, as well as the measuring devices and appliances; the procedure adopted for carrying out the experiments and the treatment of the experimental data are also described. It is explained that the stream's trajectory and the long range effect of the air screen remain unaffected when the velocity and the expenditure of air are altered, provided the relation of the momentum of the screen's stream to the momentum of the oncoming flow is constant. The basic parameter characterizing the efficiency of the air screen is shown to be the relation of the moment for the volume per second of the oncoming flow and the screen's stream. By decreasing the expenditure with simultaneous increase of the velocity of the air in the screen it is possible to obtain identical efficiency for the work of the screen, that is identical k.p.d. (the relation of the weight of air held back to the weight of the whole of the air falling into the space when the screen is not working). A new plan for the screen is proposed which involves the use of air at high pressure. The screen is created by the use of air-distributors in the form of a row of constricting or of Laval nozzles. Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR

292. Men', P. G., The hydraulic resistance of a steam turbine condenser (in Russian), *Izv. Vyssh. Uchebn. Zavedenii. Energetika* no. 7, 77–83, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4893.

The paper gives the results of the experimental investigations of the hydraulic resistance of a steam-turbine condenser, carried out on a model of a two-way condenser of a turbine, type APT-12-1 with a ribbon division of the tubular assembly. Observations of the structure of the flow at the inlet and return chambers were carried out by means of special glazed observation windows. The hydraulic resistance of condenser ζ_c consists of the sum total of the resistances at the entry to the tube and its exit ζ_Σ, the resistance due to the motion of the water along the tubes ζ_t, the resistance in the inlet water chamber ζ_1 and the resistance in the return chamber ζ_2, that is

$$\zeta_c = z(\zeta_\Sigma + \zeta_t) + \zeta_1 + \zeta_2$$

where z is the number of ways. A formula is obtained for the determination of the loss of pressure in the condenser, which was based on the experimental data and the aid of Blasius' formulas for the determination of the coefficient of friction in the tubes, and the theory of the free submerged stream when calculating for the coefficient of resistance at the outlet to the tubes. As the result of his investigations, author concludes that approximately 30% of the general loss of energy due to the resistance to the passage of water into the condensing apparatus is lost in the inlet and return chambers and at the entry and exit points of the flow from the condenser tubes and ~ 70% is lost because of the resistance due to the motion of the water along the condenser tubes.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

293. Ya'shin, B. I., The flow past the valve of a disk seal and the power reaction of the flow on the valve (in Russian), *Energomashinostroenie* no. 5, 6–9, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4891.

Results are given for the experimental investigation of the distribution of pressure over the surface of a gate-valve in a tube at different angles of closure of the valve. An analysis is given of

the delineation of the flow passing around the valve at different angles of closure and calculations are made for the coefficients of torsional moment on the shaft of the gate-valve, also for the deflection moments acting on the cantilever half of the gate, and for the deflection moment acting in the section of the gate perpendicular to the axis of the valve. The components of the hydrodynamic forces and of their coefficients are determined.

I. E. Idel'chik
Courtesy Referativnyi Zhurnal, USSR

294. Kadosch, M., The mechanism of jet deflection (in French), Publ. Scient. Tech. Min. Air, France no. 124, 155 pp. 1959.

Significant report concerns experimental and theoretical studies made in France during more than a decade on the phenomenon of jet deflection. Best known use of work has been to provide thrust reversal in jet engines. Second purpose is to obtain changes in jet direction for flight control.

Mechanisms studied include:

a. effect of relatively small obstacle placed in center of jet. (in S.N.E.C.M.A. design the deflected jet is then made to traverse a cascade of highly cambered airfoils which further change the direction of flow to give negative thrust).
b. deflecting main jet flow by small transverse jets.
c. deflection by making the jet adhere to a curved wall.

Report covers qualitative and quantitative wind-tunnel tests and analysis for incompressible and compressible flow.

R. P. Kroon, USA

295. Lyshevskii, A. S., The influence of the surrounding medium on the disruption of a hollow jet of liquid (in Russian), *Izv. Vyssh. Uchebn. Zavedenii. Energetika* no. 6, 108–112, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5027.

An investigation is carried out of the stability and the conditions governing the breaking up of a jet of liquid issuing from a round orifice, the basis of the investigation being the application of the method of small disturbances. The liquids (the jet and the surrounding medium) are taken to be ideal, incompressible and imponderable with their motion-potential and symmetrical. When analyzing the stability of the ring jet it is assumed that the conditions of development of the disturbances from the inner and outer sides are wholly identical. When this is the case the solution of the problem is simplified to a considerable extent. The author, after bringing into operation the usual boundary conditions for the surfaces of the hollow jet, arrives at a quadratic equation for the vibrations' increment, the solution of which opens up the possibility of determining the influence of a number of parameters on the characteristics of the jet's stability. It is shown that with a decrease in the film thickness the magnitudes of the maximum values of the vibrations' increment become larger, which means that the time of the break-up or the length of the unbroken part of the jet shorten as the attenuation of the cylindrical film becomes more marked. It was also established that with an increase of Weber's criterion $W = u^2 q_1 r_2/\sigma$ (where u is the velocity of the jet, q_1 the density of the medium surrounding the jet, r_2 the external radius of the cylindrical film, σ the coefficient of surface tension) and an increase in the relation $q = q_2/q_1$, where q_2 is the density of the jet's liquid, the maximum value of the vibrations' increment increases and moves toward the region of large wave numbers; that is, here again the length of the unbroken portion of the jet shortens and the film breaks up into smaller fragments.

Yu. F. Dityakin
Courtesy Referativnyi Zhurnal, USSR

296. Curtet, R., Flow of a jet stream in a confined space (in French), Publ. Scient. Tech. Min. Air, France no. 359, 114 pp., 1960.

A unified description is given for point and line jets mixing with a confined flow of the same fluid. Similarity of velocity distributions in the jet is used. The frictional boundary layer is introduced to express the friction along the confining boundaries. The results are verified by the author's own experiments and by those of others.

H. A. Einstein, USA

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 330, 332, 335, 341, 344, 345, 367, 368, 370, 371, 373, 400, 401, 403, 427, 430, 463, 473, 475, 483, 493, 507, 556, 557)

Book—297. Brun, E. A., and Martinot-Lagarde, A., Mechanics of fluids, Vol. 1: Part 1, Generalities—statics; Part 2, One-dimensional flow—conduits [Mécanique des fluides, Tome 1: Fascicule 1, Generalites-Statique; Fascicule 2, Écoulements a une dimension-conduites], Paris, Dunod, 1959, xxi + 264 pp.; 1960, xiii + 316 pp. 2500 F. (Paperbound)

This volume, in two parts, forms the first of a set of three in which the authors intend to present a work on fluid mechanics, ranging from its basic ideas to the most recent developments. The second volume will discuss two- and three-dimensional flows at speeds ranging from subsonic through supersonic to hypersonic. In volume three the various methods of measurement will be surveyed and several applications of the subject (e.g. hydraulics, lubrication, meteorology, etc.) will be described.

In the present volume the presentation is excellent and every effort is made to clarify any difficult points, though at times the argument becomes somewhat labored and the text verbose (but these are not necessarily defects in a book designed as a text for students). Throughout the detailed analysis the authors never lose sight of the physical reality underlying the mathematics. In particular it is pleasing to find a reasonably detailed description of real fluids preceding the treatment of ideal fluids and perfect gases, with some effort made to estimate the relevance of the latter as an approximation to the former.

In part I the first section consists of a review of the basic concepts. These include the properties of fluids (viscosity, thermal conductivity, compressibility, etc.), mathematical tools (tensor algebra, vector calculus, etc.), dynamical ideas, thermodynamics, acoustics, physical similarity and lastly a brief description of the optical methods used in experimental studies. Each chapter is self-contained and concise. Reviewer found the exposition of thermodynamics particularly lucid. The second section in Part I is a survey of fluid-statics. The first three chapters are concerned with hydrostatics and floating bodies, a chapter follows on the statics of a compressible fluid and the section concludes with a brief summary of surface tension. Reviewer considers that this last chapter has been over-compressed and a student will find it difficult to complete the proofs of some theorems without additional reading.

Part II consists of a most detailed analysis of steady, non-viscous one-dimensional flow, an extension of which is made to the case of viscous fluids by the introduction of an appropriate coefficient of friction upon the walls of the tube in which the flow takes place (be it an elementary stream tube, or a pipe of almost constant cross section), the justification for which is based essentially upon experimental observation. A further extension is also made to include the effects of heat conductivity. Adiabatic but nonisentropic flows of a gas receive careful study and it is noteworthy that the different aspects and interpretations of Bernoulli's equation receive clear and adequate review. The properties of shock waves are discussed and detonation waves are

briefly mentioned. With particular reference to gravity waves, a chapter is also included on one-dimensional flow of a liquid with a free surface, and the well-known analogy between such a flow and that of a gas in a pipe is established. The above studies comprise the third section of the volume. Section IV is restricted to a consideration of the manner in which mechanical energy may be lost to a real fluid in one-dimensional flow. Viscosity is here examined and some account given of laminar and turbulent flows.

Throughout the volume the chapters conclude with useful sets of exercises (referred to in the main text) which emphasize the physical importance of the theory. A student working from the book alone should obtain a sound knowledge of one-dimensional fluid dynamics of steady flow. A comprehensive index is given at the end of the complete volume, but it is a pity that there is a complete absence of references to other texts or papers on the subject to aid the student in further study. However the reviewer believes that a more serious omission is that there is no treatment of unsteady flows; in particular nowhere in the book is any mention made of the method of characteristics. It is to be hoped that when the promised mathematical analysis of two-dimensional steady supersonic flow appears some reference will be made to the similar analysis of one-dimensional unsteady flow. Nevertheless the volume is a welcome addition to the texts on fluid dynamics. As one has come to expect from the French, the printing and layout are excellent, the price is most reasonable, and there are few typographical errors. J. B. Helliwell, Scotland

298. Oswatitsch, K., Similarity and equivalence in compressible flow, Advances in Applied Mechanics, Vol. 6, New York, Academic Press, Inc., 1960, pp. 153–271.

Author is interested in the mechanical similarity rules regardless of the Mach number range to which the flow in question belongs. The classical mechanical similarity theory establishes the conditions under which experimental results obtained with small-scale model would promote a basis for predicting the behavior of full-size bodies. The author collected all the possible similarity rules valid in the gasdynamics domain (viscosity neglected), including hypersonics and unsteady flows.

In Part I after developing the fundamental equations governing the motion, the author explains and defines the realms of gasdynamics: sub-, trans-, super-, and hypersonic. In the subsequent sections the following items are covered: approximations for the speed, the direction of the velocity, the pressure coefficient; the shock equations for small disturbances; boundary and initial conditions; simplifications of the boundary conditions for thin profiles and wings; simplifications of the boundary conditions for bodies of revolution; linearization of gas-dynamic equation; corresponding points; transformation of the velocity components. In Part II the author treats the applications of the linear theory; the following items are discussed: the Prandtl-Glauert analogy; the effect of compressibility for bodies of revolution at zero incidence; application of the Prandtl rule; limits of the domain of linearization; Mach number dependence of the aerodynamic forces on a wing. Part III deals with higher approximations: higher approximations for the gasdynamic relations; the shock equation in nonparametric representation; reduction of the differential equations.

Part IV covers the transonic similarity: similarity laws for profiles and wings in transonic flow; transonic flow past profiles and wings at nonzero incidence; bodies of revolution in transonic flow; transonic flow past a circular cone. Part V discusses the hypersonic similarity: similarity laws in hypersonic flow; hypersonic flow at nonzero incidence. Part VI refers to unsteady flows: reduced frequency. Part VIII, bodies of low aspect ratio: bodies of low aspect ratio at nonzero incidence; bodies of low aspect ratio at zero incidence; law of equivalence; Mach number dependence of wings with low aspect ratio; area rule and similarity.

The paper contains a large number of diagrams and is based upon many references from the past. Due to the fact that it covers all the domains of gasdynamics and cuts across the barriers of particular ranges, it is a valuable addition to the library of a gasdynamist. M. Z. v. Krzywoblocki, USA

299. Grigorian, S. S., Limiting self-similar one-dimensional, non-steady motions of a gas (Cauchy's problem and the piston problem), *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22,** 3, 417–430, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author follows up previous work [AMR **12**(1959), Rev. 4005] by considering limiting flows representable by self-similar models, which reduce equations of nonsteady isentropic flow of ideal gas to ordinary differential form. G. Power, England

300. Legendre, R., Conformal mapping of a circular polygon: Application to the study of a two-dimensional compressible flow (in French), ONERA Publ. 94, 73 pp., 1959.

The study of the properties of Eulerian functions is aimed at the use of these functions in the calculation of the hypergeometric function.

The differential equations related to the conformal transformation of the circular polygon are then studied and the problem of the uniformization of these solutions is posed. The calculation of the first uniformizing function is accomplished in the general case. The second uniformizing function is only calculated in the case of the circular triangle with the aid of the hypergeometric function or of equivalent functions. Some indications on the ζ function series presage a further generalization.

An application to the study of two-dimensional compressible flow is particularly illustrated by the calculation of a cascade of lifting airfoils.

According to reviewer the paper appears to be a useful and excellent piece of work.

From author's summary by Alberta Alksne, USA

301. Bogacheva, A. V., Laminar high-speed air flow in flat capillaries, Akad. Nauk Press, Moscow, 1959, 194–204. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton Mass., Pap. B–153, 10 pp.)

302. Depassel, R., Flow of air at high velocity in a circular wind tunnel (in French), Publ. Scient. Tech. Min. Air, France no. 360, 98 pp., 1960.

Paper presents a theoretical and experimental study of the subsonic flow of a compressible gas in an insulated circular tube. Calculations are made for laminar boundary layers, turbulent boundary layers and the established pipe flow regime. The boundary layer equations are written in an integral form and an approximate method of solution is proposed which is said to be superior to previous methods. A one-dimensional flow theory is also presented. Experimental results are given for a particular configuration and these are compared with the results given by the various theories. G. A. Bird, Australia

303. Tomita, Y., A study of high speed gas flow by hydraulic analogy (The 4th report, Flow around an airfoil), *Bull. JSME* **2,** 8, 663–669, Nov. 1959.

Scale effects in [use of] a water table as an hydraulic analog of high-speed gas flows are discussed. Empirical formulas for correction of analog data to obtain better agreement with wind-tunnel tests are presented for pressure distributions around airfoil sections. Reviewer believes that analog is of greatest use for qualitative studies of transonic flows and that use of correction factors compensate for scale effects permit quantitative results to be obtained. D. W. Appel, USA

304. Tricomi, F. G., Mathematical questions in transonic gas dynamics (in German), *ZAMM* **39,** 9/11, 445–453, Sept./Nov. 1959.

Author's name is associated with the investigation of partial differential equations of mixed type called Tricomi or T-equations

$$y(\partial^2 z/\partial x^2) + (\partial^2 z/\partial y^2) = 0$$

into which the basic relations in transonic flow can be transformed.

Author discusses the problem of existence or nonexistence of transonic potential flow past an airfoil with reduction on boundary-value problems in hodograph plane joined with the general Tricomi problem and considers the right answer depends on the conservation of physical plane. Present theoretical results in transonic gasdynamics are based on indirect method of solution, but considering T-equation as fundamental, a solution of transonic flow in Laval nozzle is obtained. In other cases special solutions of T-equations lead to Gauss hypergeometric functions. As a further fundamental equation a known relation of Tomotika-Tamada is used which author transformed to a form which permits technically important particular solutions.

M. Horejsi, Czechoslovakia

305. Wegener, P. P., Experiments on the departure from chemical equilibrium in a supersonic flow, *ARS J.* **30,** 4, 322–329, Apr. 1960.

Stationary supersonic nozzle flow of a reacting gas mixture, in thermodynamic equilibrium or in states between equilibrium and frozen flow, was investigated experimentally and analytically. With this fully determined flow system, it was possible to check various criteria to predict departures from equilibrium. A method proposed by Bray for Lighthill's ideal dissociating gas was extended to author's real gas system, and the results showed agreement with the experiments.

From author's summary by W. Wuest, Germany

306. Probstein, R. F., and Kemp, N. H., Viscous aerodynamic characteristics in hypersonic rarefied gas flow, *J. Aero/Space Sci.* **27,** 3, 174–192, 218, Mar. 1960.

The rarefied flow in the stagnation point region of blunt bodies is considered. On the basis of an order-of-magnitude analysis [AMR **12**(1959), Rev. 1382] several flow regimes are distinguished in the order of decreasing Reynolds (and Knudsen) numbers between the ordinary flow with a boundary layer and the free molecule regime: (1) a vorticity interaction regime, previously treated [AMR **13**(1960), Rev. 293], where the vorticity of the flow in the inviscid shock layer between the shock wave and the boundary layer becomes sufficiently large so that the boundary-layer equations must be modified, (2) a viscous layer regime, where the whole shock layer is viscous, but the shock wave remains thin, (3) a merged layer regime, where the shock wave can no longer be taken as a discontinuity but merges with the shock layer behind, (4) a transitional regime, (5) a first-order collision regime, where the kinetic theory must be applied.

The purpose of the paper is to show that a treatment of regimes (2) and (3) is possible by using continuum concepts, i.e. by applying the Navier-Stokes equations to the flow in the stagnation point regions, provided adequate boundary-value conditions are taken. These conditions are given for case (2) by the Hugoniot-Rankine equations for the shock wave, while for case (3) these equations are replaced by similar conditions derived by a Navier-Stokes treatment of the shock wave, including finite thickness, curvature, viscous stresses and heat flow.

In this way the flow in front of a sphere and a cylinder is examined, spherically and cylindrically symmetric solutions of the Navier-Stokes equations being derived, valid in the stagnation region. The outlined procedure, while perhaps not providing the detailed structure of the flow, should at least give the mean aerodynamic quantities, such as surface shear and heat transfer. Numerical computations show in the cases examined that these quantities first increase above values given by the boundary-layer theory, and begin to decrease at lower Reynolds numbers. The detachment distance of the shock wave increases at lower Reynolds numbers. Qualitative agreement with existing experimental data is indicated.

This work is most valuable as it carries as far as possible the treatment of rarefied gas flows, employing the continuum concept, by a proper use of the Navier-Stokes equations. However reviewer thinks that especially for hypersonic flows behind strong shock waves, the thermodynamic nonequilibrium becomes so strong that the first-order (Navier-Stokes) approximation to the Boltzmann equation may no longer be adequate at lower Reynolds numbers, and a kinetic theory approach might prove of interest.

L. Z. Dumitrescu, Roumania

307. Feldman, S., On hypersonic wakes in the atmosphere, *Physics of Fluids* **3,** 3, 479–480 (Letters to the Editor), May/June 1960.

The purpose of this note is to summarize some recent work concerning the features of the flow field in the trails left in the atmosphere by blunt nonablating bodies moving at hypersonic speeds. From author's summary

308. Pottsepp, L., Inviscid hypersonic flow over unyawed circular cones, *J. Aero/Space Sci.* **27,** 6, 558–559 (Readers' Forum), June 1960.

The purpose of this note is to present an approximate closed-form solution to the inviscid hypersonic flow field over a circular cone at zero angle of attack. From author's summary

309. Whalen, R. J., Viscous hypersonic similitude for a dissociating gas, *J. Aero/Space Sci.* **27,** 6, 550–551 (Readers' Forum), June 1960.

310. Wood, R. D., A heated hypersonic stagnation-temperature probe, *J. Aero/Space Sci.* **27,** 6, 556–558 (Readers' Forum), June 1960.

311. Winter, D. F. T., Multiple shock compression using a piston of finite weight, *J. Fluid Mech.* **8,** 2, 264–272, June 1960.

Paper describes theory for a piston-operated compressor in which shock waves are used to heat the gas being compressed. Detailed calculations are given showing the use of such a compressor to heat air for use in a hypersonic wind tunnel. The effect of real gas properties on the compression process is included.

From author's summary by R. A. Gross, USA

312. Charrueau, A., On shock waves (in French), *Ann. Ponts Chaus.* **129,** 5, 497–548, Sept./Oct. 1959.

Author studies the geometric and kinematic transformation which a continuous medium undergoes as a shock wave passes through it. Author, using matrix calculus, gives a detailed study of the motion with deformation of an infinitesimal parallelopiped when the wave has a positive velocity of propagation.

G. Sestini, Italy

313. Love, E. S., Henderson, A., Jr., and Bertram, M. H., Some aspects of air-helium simulation and hypersonic approximations, NASA TN D-49, 84 pp., Oct. 1959.

Discussions concern the possibility of air-helium simulation for viscous and nonviscous hypersonic flows. Results of some recent studies on this problem are compiled and simple expressions are presented for achieving simulation of parameters in various cases. Most of them are applicable to any two gases having different specific heat ratios. Imperfect-gas effects are not considered throughout. Results show that it is possible to obtain sufficient simulation for many types of hypersonic problems.

R. Kawamura, Japan

314. Sichel, M., The calculation of velocity and temperature profiles through a weak normal shock with an expansion in powers of a shock strength parameter, AFOSR TN 60-83 (Princeton Univ., Dept. Aero. Engng. Rep. 488), 60 pp., Nov. 1959.

A series expansion in powers of shock strength is used to solve the Navier-Stokes equation as if it is exact. The effects of second viscosity coefficient, variable viscosity and Prandtl number are included, while the specific heats were treated as constant. The velocity and temperature are expressed directly as functions of the position. Comparison with numerical solution at an upstream Mach number slightly above two is made; the numerical solution had been compared with experiments in listed references to upstream Mach number of about four.

From author's summary by W.-H. Chu, USA

315. Goldsmith, E. L., and Griggs, C. F., The estimation of shock pressure recovery and external drag of conical centre-body intakes at supersonic speeds, Aero. Res. Counc. Lond. Rep. Mem. 3035, 66 pp., 1959.

Authors discuss work done between 1950 and 1952 on Pitot-type intakes with fixed center bodies, at Mach numbers between 1.5 and 2.5. Pressure recovery and external drag are measured under subcritical conditions and when spilling, and compared with theoretical values. The theory is now out-of-date.

E. Pribram, England

316. Street, R. E., Shock-wave structure based on Ikenberry-Truesdell approach to kinetic theory of gases, NASA TN-365, 60 pp., Feb. 1960.

A brief review of the Ikenberry-Truesdell method of solving the Boltzmann equation is given with emphasis on the so-called Maxwellian iteration. This method is applied to the problem of shock-wave structure. A series solution is used to find the velocity and temperature profiles for a steady, plane shock-wave in a perfect gas of Maxwellian molecules. The results are not significantly different from the Navier-Stokes solution. The advantage of the present method is that the form of the distribution function need not be specified.

From author's summary by D. Ter Haar, England

317. Rudinger, G., Passage of shock waves through ducts of variable cross section, *Physics of Fluids* **3,** 3, 449-455, May/June 1960.

If shock waves strong enough to produce supersonic flow pass through a duct of variable cross section, the shape of which is approximated by a single discontinuous area change, a variety of wave patterns may be found. These are unique for particular conditions except for a range of area convergence for which it was recently shown that three solutions exist. Examination of the transient processes that precede the establishment of the final flow suggests, and a general proof confirms, that only one of these solutions can actually be realized if the duct converges monotonically. For more general duct configurations, the other solutions may also be found, but the correct wave pattern may have to be established with the aid of a wave diagram in which area changes are properly taken into account. For configurations with a throat, additional wave patterns may appear both within and outside of the region of ambiguity which then loses its significance.

From author's summary

318. Gonor, A. L., On the location of the bow wave in nonsymmetric hypersonic gas flow around a pointed body (in Russian), *Izv. Akad. Nauk USSR, Otd. Tekh. Nauk (Mekh. i Mash.)* no. 5, 117-118, 1959. (Translation by Morris D. Friedman, Inc., P. O. Box 35, W. Newton, Mass., Pap. G-167, 3 pp.)

319. Stollery, J. L., and Maull, D. J., A note on shock detachment distance, *J. Roy. Aero. Soc.* **64,** 594, 357-359 (Tech. Notes), June 1960.

320. Narasimha, R., Nearly free molecular flow through an orifice, *Physics of Fluids* **3,** 3, 476-477 (Letters to the Editor), May/June 1960.

321. Pack, D. C., A note on the breakdown of continuity in the motion of a compressible fluid, *J. Fluid Mech.* **8,** 1, 103-108, May 1960.

The question of whether a compression front in the one-dimensional cylindrical or spherical symmetrical flow of a compressible inviscid fluid will result in the breakdown of the continuous flow is considered here.

The present work presents an analytical approach which examines the compatibility conditions along the characteristic surfaces in the flow field and shows that the velocity gradients must at some time take on infinite values which then result in a discontinuous flow field.

Previous work along this line has already been carried out, but the present work presents a rigorous analytic argument leading to the conclusion that noncontinous solutions must result for this type of flow. It is shown that, for spherical waves, the discontinuity is of such an order of smallness that it could not have been detected by a purely numerical investigation.

The work presented here will find its greatest use among those interested in theoretical theory of compressible fluid motion, especially those concerned with spherical blast phenomena.

K. A. Faymon, USA

322. Papadopoulos, V. M., A line source on an interface between two media, *J. Fluid Mech.* **8,** 1, 41-48, May 1960.

The nature of the field of a line source which is set up at some time on the plane interface between two different homogeneous fluids is investigated here. An analytical solution is presented for the case where this line source may have a step function character or a Delta function character. Utilizing similarity principles, along with linearized equations of state and the assumption of weak sources in order for the acoustic approximation to be made, the velocity potential of the unsteady line source is obtained. These results are then shown to be applicable to the problem of calculating the fields due to a semi-infinite line source of uniform strength which moves with a supersonic velocity relative to both fluids along the interface between these fluids. It is also shown that this solution is applicable to problems in the theory of electromagnetic pulses involved in the sudden setting up of a current in an infinite line or of a charged line on the interface of two media. This paper will be of greatest interest to those concerned with the theoretical analysis and mathematical methods involved in such problems. K. A. Faymon, USA

323. Chopin, S., Note on the connection between unsteady formulas for supersonic and hypersonic pressure (in French), *Recb. Aéro.* no. 77, 53-54, 1960.

324. Stingelin, V., Isothermal nozzle flows (in German), *Astronaut. Acta* **6,** 1, 61-74, 1960.

Paper presents some theoretical and numerical calculations carried out for estimating prospects of isothermal nozzle expansion in nuclear jet propulsion devices. Flow process considered may consist of initial heating of propulsion fluid at constant pressure, followed by isothermal and residual adiabatic expansions. Using fundamental aerothermodynamic relations, it is first shown that, disregarding relativistic effects, isothermal expansion velocity may become infinite for zero nozzle exit pressure (space propulsion). Turbulent heat transfer from nozzle wall to gas with friction pressure drop is then calculated by means of Reynolds analogy. For an assumed constant difference between nozzle wall and mean gas temperatures, possibility of very high isothermal expansion velocities still would exist if only mechanical viscous effects were present. Effect of boundary layer with

stagnation temperature recovery is then analyzed and a maximum velocity attainable under resulting limited heat-transfer conditions is computed, showing influence of recovery factor r. For $r = 1$, maximum final expansion velocity is found to be equal to maximum adiabatic expansion velocity obtained after conventional isobar heating. For $r = 0.9$, only 5% velocity increase results. Shape and length of isothermal nozzle are calculated and discussed, too.

Finally, nozzle wall temperature distribution along axis is calculated for isothermal gas expansion combined with given reactor heat production per unit of nozzle length. Comparison with isobar heat transfer shows even higher wall temperature peaks for isothermal case. Limited improvement only may be achieved by optimally combining isobar heating and isotherm heat transfer and expansion processes.

It is concluded that presence of nozzle thermal boundary layer practically annihilates isothermal expansion effect in generating high velocities.

Stimulating and comprehensive, paper provides a valuable clarification of an important aerothermodynamic aspect of nuclear jet propulsion. P. Schwaar, USA

Boundary Layer

(See also Revs. 275, 280, 283, 302, 371, 427, 434, 445, 450, 457, 563)

325. Schubauer, G. B., and Spangenberg, W. G., Forced mixing in boundary layers, *J. Fluid Mech.* **8,** 1, 10–32, May 1960.

Paper covers much broader field than indicated by title. Behavior of boundary layers in adverse pressure gradients was studied with particular reference to the location and pressure recovery of separation. Experiments were made on the action of artificial devices to increase the rate of mixing in the boundary layer. Effectiveness of devices was then compared to natural means (small pressure gradient) in the delay of separation.

Experiments were carried out in a special two-dimensional wind tunnel. Pressure and velocity distributions were measured along the floor and the separation line defined through a dust deposition method. A steep pressure gradient was created which produced separation within 5 feet. Various mixing devices, each about the height of the boundary-layer thickness, were attached to the floor and the optimum position and spacing determined. Separation was delayed and pressure recovery increased in every case. Devices differed in the means of moving the high-velocity flow toward the wall, hence in their effectiveness and drag penalty. For analysis of the real benefit of the mixing devices, natural pressure gradients were created having the same pressure recovery at separation. It was found that there was similarity of flow properties provided the natural gradient had the same shape. One natural gradient was made with a steep slope at the start and a progressively milder slope downstream. This was more effective than the linear gradients.

Reviewer believes that this paper is a major contribution to the understanding of flow with adverse pressure gradients. It will provide the designer with useful information about diffusors, boundary-layer suction devices and high-lift airfoils.

W. D. Baines, Canada

326. Kubanskii, P. N., On the theory of vortex formations in the vicinity of a resonator subjected to air streaming, *Soviet Phys.–Acoustics* **5,** 3, 331–338, Feb. 1960. (Translation of *Akust. Zh., USSR* **5,** 3, 324–331, July/Sept. 1959 by Amer. Inst. Phys., New York, N. Y.)

Consider regular holes in an otherwise plane wall with attached turbulent boundary layer. It is known from experiments by Wieghardt (see H. Schlichting: "Boundary layer theory") that for a certain ratio of depth to width of the holes a large increase in the frictional resistance occurs. Author made qualitative experiments with lycopodium powder to determine the flow form in the cavity. He concludes that an unsteady flow develops in the cavity giving rise there to periodical development and discharge of rotational flow. In an investigation of the quasi-steady flow in the cavity the conditions at the free surface of the neck are derived from the known lateral spread of a free jet. Results agree with experiments by Gavreau [*Acustica* **4,** 5, p. 555, 1954]. The flow inside the cavity is found from Navier-Stokes equations neglecting inertia terms. As an example streamlines are given for air flow in a cylindrical cavity of 1-cm radius and free-stream velocity outside the boundary layer of 10 m/s.

Reviewer notes that for the size of cavities considered the above neglect of the inertia terms would be erroneous and hence the author's solutions would not be applicable for the flow in the cavity. H. Schuh, Sweden

327. Broecker, E., Theory and experiments concerning the frictional resistance of flat rotating disks in turbulent flow (in German), *ZAMM* **39,** 1/2, 68–76, Jan./Feb. 1959.

Paper considers the momentum-integral theory of the turbulent boundary layer on a rotating disk in a casing, and compares it with known experimental results for the flow.

J. T. Stuart, England

328. Townsend, A. A., The development of turbulent boundary layers with negligible wall stress, *J. Fluid Mech.* **8,** 1, 143–155, May 1960.

In this altemative version of Stratford's work [AMR **13**(1960), Revs. 1302 and 1303] author obtains a criterion for separation in a strong adverse pressure gradient and gives details of a self-preserving flow with zero wall stress. Stratford considered two layers. In the inner layer the pressure force is balanced by the shear force gradient, while in the outer layer the pressure force causes simply a reduction in dynamic head. Stratford also described a self-preserving flow with zero wall stress.

Author refines the analysis of Stratford. He considers that the theoretical basis is sound and, indeed, is an improvement on other simplifications which have been used but that doubt about how much interaction there is at the junction of the two layers makes accurate prediction of separation by Stratford's method unlikely. Finally author gives a theory for self-preserving zero wall stress flows which fits well with Stratford's experiments if an empirical constant is chosen suitably. J. C. Cooke, England

329. Stewartson, K., and Howarth, L., On the flow past a quarter infinite plate using Oseen's equations, *J. Fluid Mech.* **7,** 1, 1–21, Jan. 1960.

Paper deals with laminar flow across a quarter-infinite flat plate for which the leading edge is normal to, and the side edge parallel to, the uniform free-stream velocity. The physical problem thus differs from the classical Blasius situation through inclusion of the side-edge effect.

The analysis is based upon Oseen's equations, and it is shown that the cross flow in the side edge region does not possess similarity properties. This occurs through the boundary-layer effects upon the potential flow, and as a consequence the cross flow is dependent upon the shape of the leading edge.

R. D. Cess, USA

330. Rotta, J., The influence of Mach number and heat transfer on the law of the wall in turbulent flow (in German), *Z. Flugwiss.* **7,** 9, 264–274, Sept. 1959.

The similarity law of turbulent flow along a wall is extended to the case of compressible flow with heat transfer. Additional parameters used are a Mach number and heat-transfer coefficient based on shear velocity. After formulating the problem mathemati-

cally, some calculations are carried out using simplifying assumptions and are compared with published experimental results. The results are discussed. Equations are given for the velocity and temperature distributions in the fully turbulent region.

From author's summary by W. L. Habeman, USA

331. Brun, E. A., editor, Seminar on aero-thermodynamics at the Faculty of Sciences, Paris, for the year 1956–57 (in French), Publ. Sci. Tech. Min. Air, France N. T. 73, 192 pp., Mar. 1958.

This collection of papers presented in 1956/57 contains many interesting and penetrating expositions in the study of boundary layers, turbulence, and convective heat transfer. Although some of the material is now somewhat dated it still represents worthy study for workers in these fields.

In the first group of papers dealing with the experimental study of the boundary layer, Favre discusses results obtained for space-time correlations and spectra of turbulence both downstream of a gauze and in the turbulent boundary layer on a flat plate. Attention is drawn to the determination of the length scales of the turbulence from instantaneous space correlations and the temporal (birth-death) scales from space-time correlations and the use of Taylor's hypothesis in a turbulent shear flow. These several results throw some light on the structure of the turbulent boundary layer. Two papers respectively by Latron and Gontier describe the use of the differential (or schlieren) interferometer for the qualitative and the quantitative study of compressible fluid flows. This system employs either a Babinet compensator or Woolaston biprism and makes use of the principle of double refraction, and hence of interference between the ordinary and extraordinary rays. Since the systems are color sensitive they possess greater sensitivity than either the conventional black and white schlieren system or the Mach-Zehnder interferometer.

The measurement of total pressure in a turbulent compressible boundary layer using total head tubes of various shapes is discussed by Plan. Although not refering to the displacement effect as such, he shows that this effect is reduced as the ratio of tube size to the boundary-layer thickness is reduced. He notes the displacement effect is different for different tube geometries. Finally in this group Thureau discusses the measurement of temperature by making use of the thermo-sensibility of fluorescent materials coated on a surface. By suitable choice of material, temperatures from 0°K to 800°K could be measured.

In the second group Michel reviews shock wave-boundary layer interaction with emphasis on boundary-layer development around airfoils in transonic flow. Some measured boundary-layer profiles on wall-mounted circular arc airfoils are also presented. It is shown that except near separation the boundary-layer development across a shock wave can be obtained from conventional boundary-layer theory provided the measured pressure distribution is used. Martinot-Lagarde shows, by the use of the shadowgraph technique, that in transonic flows shock waves exist when the Mach number is of order 1.03 or greater, whereas pressure measurements showing continuous changes in pressure do not show this phenomenon clearly.

In the third group Ribaud discusses turbulent convection in a pipe for a fluid of large Prandtl number. From a description of the velocity distribution across the temperature layer he obtains a relation between Nu, R, Cf and σ. Monaghan, Crane and Picken then review their work on the effect of cooling and incidence on transition on a cone at supersonic speeds, and on turbulent heat transfer at supersonic speeds. They show that the various methods employed for indicating transition (surface pitot, shadowgraph, schlieren, sublimation, and oil flow) are reasonably consistent. Over the range of test Mach numbers cooling the cone at zero incidence increased the transition Reynolds number. Transition was found to be a function of incidence to semi-nose angle, and on the lower surface transition moved aft with incidence, whereas on the upper surface it moved forward with incidence. Transition was found to move aft on the lower surface with cooling but no movement was found on the upper surface. The turbulent heat-transfer results were found to be consistent with an intermediate enthalpy method based on Reynolds analogy.

In the final group of papers Cordier discusses a new method of measuring the local rate of heat transfer from a surface. Locally the metal surface of the body is replaced by a plug of poor thermally conducting material, such as plexiglas, covered with a resistance film. It is shown that the local heat flux to the body is, to a good approximation, equal to the heat input to the resistance film when the temperature of the latter is made equal to the surface temperature of the surrounding metal body. Gosse shows that the measurements of the heat lost by thin wires placed perpendicular to a flow at very low Reynolds numbers are consistent with theory when allowance is made for free convection and conduction. The importance of the latter term is considerable for Reynolds numbers less than seven and explains the anomalous behavior of the results of Cole and Rashko (1954) with round wires of various length/diameter ratios and of Richardson and Winny (1924) with round wires at various distances from a wall. The final paper by Doussain discusses the calculation of the performance of heat exchangers under steady-state conditions.

G. M. Lilley, England

332. Crawford, D. H., Investigation of the flow over a spiked-nose hemisphere-cylinder at a Mach number of 6.8, NASA TN D-118, 59 pp., Dec. 1959.

Experimental investigation at free-stream Reynolds number of 0.12×10^6 to 1.5×10^6. Effects of spike length and Reynolds number on separated boundary, including transition to turbulent flows, were found. Main results are: the integrated heat transfer to the hemisphere was increased by the spike over the Reynolds number range 0.3×10^6 and 1.5×10^6, but decreased at the lowest Reynolds number of 0.14×10^6 to 0.17×10^6; thus heat transfer is dependent on the state of the flow; the pressure drag coefficient of the hemisphere-cylinder is reduced by the spike; the ratio of drag to heat transfer was reduced by the spike; the transition Reynolds number for the separated boundary layer was less than for a solid boundary.

H. G. Lew, USA

333. Walz, A., Contribution to the approximation theory of compressible turbulent boundary layers (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 84, 56 pp., Mar. 1959.

A previous method [AMR **10**(1957), Rev. 234] for compressible laminar and turbulent boundary layers is further developed to include heat transfer. At first, general integral relations are derived for the temperature field analogous to those existing for the velocity field. The lowest order of these are selected to provide an energy and a momentum equation for calculation.

To solve the turbulent case, additional assumptions are introduced: the temperature profile is related to the velocity profile; a one-parameter velocity profile is assumed; the existing incompressible empirical relations for the local skin friction and dissipation function are generalized for heat transfer.

Calculated drag coefficients for a flat plate show good agreement with test results as a function of Mach number and heat-transfer factor.

P. S. Granville, USA

334. Chang, P. K., Differential equation of compressible turbulent skin-friction coefficient around an arbitrary body of revolution at high speed, *J. Aero/Space Sci.* **27,** 6, 466–467 (Readers' Forum), June 1960.

335. Makofski, R. A., On the use of the boundary-layer equations in the hypersonic viscous-layer regime, *J. Aero/Space Sci.* **27,** 6, 468–469 (Readers' Forum), June 1960.

336. Beckwith, I. E., Similar solutions for the compressible boundary layer on a yawed cylinder with transpiration cooling, NASA TR R-42, 37 pp., 1959.

See AMR **12**(1959), Rev. 3081.

337. Bouligand, G., Theoretical possibilities of states of flow of a liquid, between laminar and turbulent (in French), *C. R. Acad. Sci., Paris* **249**, 14, 1169-1171, Oct. 1959.

338. Friedlander, S. K., and Litt, M., Rapid chemical reaction in a laminar boundary layer, *Appl. Scient. Res. (A)* **8**, 6, 403-412, 1959.

After making the usual expedient assumptions the equations of the compressible laminar boundary layer with chemical reaction are simplified so that the specific enthaply of the mixture and the concentrations of the species admit solutions which are linearly dependent only upon the local velocity. The velocity distribution satisfies the Blasius equation after, again, the usual Chapman-Rubesin transformation. All details can then be solved explicitly. Paper differs from Emmons' pioneering work [*ZAMM* **36**, p. 60, 1956; AMR **9**(1956), Rev. 3419] mainly in the different combustion model consisting of two species reacting into the "product" and an infinitesimally thin reaction zone. No reference is made to other authors who have adopted a similar approach.

S.-F. Shen, USA

339. Ludwig, G., and Heil, M., Boundary-layer theory with dissociation and ionization, Advances in Applied Mechanics, Vol. 6, New York, Academic Press, Inc., 1960, 39-118.

Paper reviews published knowledge on the problem. It consists of two independent parts—a larger first section, which examines the connection between the Boltzman equation and the computation of transport coefficients of a dissociated or ionized gas, and a shorter section, which describes known solutions of the boundary-layer equations for a reacting gas [Fay & Riddell and others].

L. Trilling, USA

340. Hassan, H. A., On a solution to the unsteady laminar boundary layer, *J. Aero/Space Sci.* **27**, 6, 474-476 (Readers' Forum), June 1960.

Turbulence

(See also Revs. 12, 275, 280, 283, 326, 327, 328, 330, 331, 334, 373, 432, 462, 463)

341. Peskin, R. L., Some effects of particle-particle and particle-fluid interaction in two phase flow systems, Proc. Heat Transf. Fluid Mech. Inst., Stanford, Calif., June 15-17, 1960; Stanford Univ., 1960, 192-207.

The intensity of motion and the diffusivity of a single particle suspended in a turbulent fluid is discussed. The statistical behavior of particle motion is considered for the case of an isolated particle and for the case in which other similar particles present in the fluid exert pressure forces on the particle.

The pressure forces which are present when more than one particle is in motion in a fluid is approximated as an inverse fourth power special force.... The correlation of the interaction force is obtained..., and the curve of the correlation shows that the dynamic friction (the tendency of many particles to decelerate one given particle) is present in the system. A stationary approximation to this correlation is used to evaluate the intensity and diffusivity of a single particle due to random pressure forces.

Conditional probability distributions and the assumption of correlation in a turbulent fluid are used to show that the diffusivity of an isolated particle in a turbulent fluid is less than the eddy diffusivity of turbulence. A specific expression for the probability of turbulent velocities encountered by an isolated particle is used to obtain its diffusivity as a function of particle radius, density and Reynolds number (based on turbulent intensity). The diffusivity is of the same order of magnitude as those obtained experimentally. When the diffusivity for the isolated particle is combined with the interaction diffusivity, the results show that the slower and larger particles are affected by the particle-particle interaction, while the faster particles behave essentially as if there were no other particles present.

From the author's summary by C. T. Chang, Sweden

342. Stemling, C. V., and Scriven, L. E., Interfacial turbulence: Hydrodynamic instability and the Marangoni effect, *AIChE J.* **5**, 4, 514-523, Dec. 1959.

Unless some simplifications are made, the connection between mathematical exposition and physical reality in problems of interfacial turbulence becomes obscure. Authors analyze a highly pruned model, not strictly realizable but displaying the salient behavior of actual systems, to provide groundwork for handling more complete models.

Analysis suggests interfacial turbulence is promoted by (1) solute transfer out of the phase of higher viscosity, (2) solute transfer out of the phase in which its diffusivity is lower, (3) large differences of kinematic viscosity and solute diffusivity between the two phases, (4) steep concentration gradients near interface, (5) interfacial tension highly sensitive to solute concentration, (6) low viscosities and diffusivities in both phases, (7) absence of surface-active agents, (8) interfaces of large extent. Analysis also shows how some systems may be stable with solute transfer in one direction yet unstable with transfer in opposite direction.

G. Power, England

343. Corrsin, S., Directional sensitivity for a finite hot-wire anemometer, AFOSR TN 60-171 (Johns Hopkins Univ., Mech. Engng. Dept.), 14 pp., 1960.

Author considers theory of heat loss and temperature distribution along a heated cylinder (e.g. a hot wire) in a moving fluid. For a cylinder of infinite length these are shown to depend only on the component of the wind normal to the wire. For cylinders of finite length the author derives a correction to be applied to the sensitivity of a hot-wire anemometer to allow for the end effect. Results are given in a graph; correction factors shown lie between 0.85 and 1.00, depending on the length of the wire and the direction of flow.

F. I. Badgley, USA

Aerodynamics

(See also Revs. 32, 220, 298, 303, 304, 311, 313, 316, 321, 326, 329, 332, 390, 495, 507, 511, 512)

Book—344. Schaaf, S. A., and Talbot, L., Handbook of supersonic aerodynamics, Vol. 5, (Bureau of Ordnance Publication, NAVORD Rep. 1488-Section 16, Mechanics of rarefied gases), Washington 25, D. C., Superintendent of Documents, U. S. Government Printing Office, Feb. 1959, ii + 74 pp. $1.25.

The stated purpose of the NAVORD handbook series is to provide information to aid in the design of supersonic vehicles. As an engineering text, therefore, articles in the handbook should avoid controversial subjects and unconfirmed data. Thus, in the present section the authors have restricted themselves to a treatment of two regimes of rarefied gas flows that are reasonably well understood, namely, free molecule and near continuum "slip" flow. The largely unexplored transition region and the various attempts to analyze it have not, for the most part, been discussed.

The largest and most useful part of the article is devoted to free molecule flow, results being based chiefly on well-established theory. Equations and charts for aerodynamic forces and heat-transfer rates are given for simple geometries, such as flat plates, spheres and cones. In view of the recent revision in expected values for particle-surface interaction parameters [Rand Report R-339, June 1959], the statement that most surfaces reflect air molecules diffusely is known to be incorrect. Thus, for example, for an artificial earth satellite it is reasoned that considerable specular reflection may occur.

Similar information on heat transfer and aerodynamic forces is given in the section on slip flow. Since slip effects in supersonic flow are superimposed on shock wave-boundary layer interaction effects, difficulty of theoretical analysis makes it necessary to give only experimental results, and the information should be applied with caution to conditions other than those of the experiments. Some of the data carries through or can be extrapolated to the free molecule limit.

In the reviewer's opinion the article provides a useful and much needed aid to the practicing engineer; the latter will, however, find that he has many questions to ask that are not answered in the article, and he will be left to his own devices. This comment does not reflect on the capability of the authors but only on the unsatisfactory state of knowledge existing in the field. Since the article was written, a few new contributions have been made. Several papers on slip flow have been written, most of them unverified experimentally, and significant progress in near free molecule flow theory and approximation methods has been made. Further experimental results in the low Reynolds number near continuum region have been reported. (See Schaaf, *ARS J.* **30**, 5, p. 443, 1960.) J. A. Laurmann, USA

345. Frankl', F. I., On the problem of symmetrical flow past a given symmetrical profile with subsonic velocity at infinity and local supersonic velocities, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 4, 1107–1114, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author extends his previous studies of the indirect method of the titled problem [*Prikl. Mat. Mekh.* **20**, no. 2, 1956; **21**, no. 1, 1957; see also AMR **11**(1958), Rev. 3160] to a direct construction of the solution within the scope of first approximation. Using the previous indirect solution which satisfied the given profile approximately, a correction term, based on the difference of the actual and approximate profiles, may be found. The existence and uniqueness of this solution under certain conditions are then established. L. N. Tao, USA

346. Gersten, K., Wing theories for subsonic velocities (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1958, 25–40.

Concise review of wing theories for subsonic steady flow is presented. Linearized theories of lift and pressure distribution, pitching and rolling moment, position of neutral point are summarized for sweptback, delta and crescent wing, including the case of nonsymmetrical flow. Effect of flaps and jet flaps is shown. Graphs are provided showing difference between theoretical and experimental values. Influence of geometrical properties of wing on the velocity distribution is also analyzed. Nonlinear theory is applied to sweptback, delta with sharp leading edge, annular wing and small-aspect-ratio wings. Graphs show the difference between linearized and nonlinearized solutions. Extensive list of references contains 64 titles. P. Bielkowicz, USA

347. Bennett, A. S., Section characteristics up to Mach 1.01 of a 6% aerofoil having a 25% chord flap at 0° and 4°, Aero. Res. Lab., Melbourne, Austral. Note A.179, 46 pp., Mar. 1960.

Comparative tests have been made on a two-dimensional Jindivik airfoil [a modified NACA 64-106 Section] fitted with a 25% chord flap set alternately at 0° and +4°. Measurements were made of lift, pitching moment and drag over the Mach number range 0.50 to 1.01 and an incidence range of −7° to +3°. As the Reynolds number of the tests did not exceed 0.6×10^6 all results were obtained with both natural and fixed transition.

From these comparative tests it was concluded that:

(1) With fixed transition for constant values of lift in the range $C_L = 0$ to $C_L = +0.4$, the use of +4° flap reduced the required incidence by just over 2° for speeds up to $M = 0.85$, but this value fell to approximately 1° or 1½° by $M = 0.92$ and remained constant thereafter. Allowing natural transition had the effect of slightly increasing the gain in incidence up to $M = 0.92$ and then to slightly decrease that gained with fixed transition.

(2) With transition fixed the lift-curve slopes of the two wings are comparable up to $M = 0.90$ but above this speed that for the +4° flap wing is higher than that for the 0° flap wing. The gain in slope reaches a maximum of 29% at $M = 0.96$ and falls to 18% by $M = 1.01$. With natural transition the slope for the +4° flap wing is higher than that for the 0° flap wing over almost the whole Mach number range.

(3) Both wings, with fixed transition, exhibit a strong pitch down tendency followed by a pitch up with rise in Mach number. Allowing natural transition only slightly modifies this behavior.

(4) For fixed transition the drag of the +4° flap wing is less than that for the 0° flap wing for $C_L = +0.2$, 0.3 and 0.4 at speeds below $M = 0.68$, 0.88 and 0.89, respectively. With natural transition a definite drag penalty results from the use of the +4° flap up to $C_L = 0.3$ but at $C_L = 0.4$ a drag saving is obtained below $M = 0.83$. From author's summary

348. Ionescu, M., and Dorie, G., Aerodynamic characteristics of a class of thin wings in high order homogeneous flow (in Roumanian), *Studii Si Cercetari Mecan. Apl.* **10**, 2, 367–377, 1959.

Paper considers the thin triangular wings whose incidence has a forced antisymmetrical variation. Proceeding from the general expression of the axial disturbance velocity, under series form, established by E. Carafoli and M. Ionescu [AMR **12**(1959), Rev. 3030], authors particularize this expression for conical motions of the order $n = 1, 2, 3, 4$. The coefficients of the respective series result after rather laborious but elementary calculations. The values obtained are used for calculating the lift, drag and moment coefficients of the wing for the above-indicated cases.

Finally, paper includes the general expression of these coefficients for the homogeneous flow of any n order.

T. Oroveanu, Roumania

349. Rosenblat, S., The aerodynamic forces on an aerofoil in unsteady motion between porous walls, *Quart. J. Mech. Appl. Math.* **12**, 2, 151–174, May 1959.

The title problem is solved for a two-dimensional, inviscid, incompressible flow. The velocity normal to the porous boundary is assumed to be proportional to the pressure difference across it and the further assumption of small rates of time change yields a tractable boundary condition.

Formulas for the pressure and moment acting in the airfoil are given in a convenient form for calculation.

L. C. Woods, England

350. Chen, C. F., and Clarke, J. H., A study of configurations composed of a body under a lifting wing in supersonic flow, AFOSR TN 59-1276 (Brown Univ., Div. Engng.), 62 pp., Jan. 1960.

Authors approach theoretical problem in three ways. An indirect method in which wing and body shapes are obtained from given configurations of singularities, optimum configurations included, and two direct methods yielding characteristics starting with given body shapes and optimum body shapes respectively.

Three rectangular and one delta wing configurations are analyzed. Parameters varied include: aspect ratio, chord/body length, thickness, gap, and some combinations of these.

Analysis makes use of slender wing and body theory and numerical calculation is performed for (a) isolated wing and Sears-Haack body, (b) combination wing and S-H body, (c) combination wing and optimum (min drag) body. Single- and double-wave reflection cases are distinguished. Results are presented as drag polar diagrams and discussed separately.

Main conclusions show that for single reflection case the maximum drag reduction (combination) is 26% of isolated drags, and body change from S-H to optimum shape results in insufficient reduction to compensate for extra calculation. However for two reflections cases, drag reduction (max 44%) is variable with gap (large gap giving lower reduction). For the delta wing the relative drag reduction is 25%.

Effects of friction are discussed and it is demonstrated that an optimum body fineness ratio (12) exists for inviscid interference flow which is less than that for isolated body in viscous flow (20).

G. Tokaty, England

351. Chen, C. F., Tests of a configuration composed of a body under a lifting wing in supersonic flow, AFOSR TN 59-1275 (Brown Univ., Div. Engng. TR WT-31), 10 pp., Feb. 1960.

A limited experimental verification of results calculated numerically via slender-body theory in AFOSR TN-59-1276 (preceding review).

Test data: $M = 1.6$, $R = 9.17 \times 10^5$ (based on body length). Rectangular wing, chord 2.05 in., span 6.82 in., thickness/chord 5%, Sears-Haack body, length 7 in., thickness/length 12%.

The boundary layer was studied visually. No significant separation occurred on wing up to test limit of 6° of incidence, nor on interior side of body. Flow separated from exterior side at angles > 0. Author examines this phenomenon and suggests that it may be obviated by kinking the body or pitching it relative to wing.

Lift test measurements agree closely with theoretical prediction. No drag measurements were reported. G. Tokaty, England

352. Patraulea, N. N., and Camarasescu, N., On the increased lift obtained by placing the propellers on the upper side of the wing (in Roumanian), *Studii Si Cercetari Mecan. Apl.* **10,** 4, 1013-1020, 1959.

Authors consider a wing of infinite span on the upper side of which severa tubed propellers are placed near the trailing edge. To estimate the suction effect due to these propellers the motion is assumed to be plane, the propellers being replaced by "active" permeable surfaces which produce a constant jump of pressure. It is also assumed that the total lift consists of that due to the suction effect corresponding to a zero incidence profile, and of the lift of the profile with a real incidence having an infinitely thin jet flap. Problem is solved by the rheoelectrical analogy. Diagrams representing the variation of the aerodynamic coefficients for several values of the geometrical parameters are given.

T. Oroveanu, Roumania

353. Mitsuyasu, A., On downwash and separation vortices of sweptback wings, *Mem. Fac. Engng., Kyushu Univ.* **19,** 2, 138 pp., Feb. 1960.

Lengthy survey article (written in a brand of English which reviewer found very hard to understand) also contains some original experimental results and calculations based on rather outmoded theories. Author reviews theory and experiment on flow past swept wings, published before 1955, from the point of view of prediction of downwash behind the wings, giving examples of downwash calculations based on assumption of either plane or completely rolled up vortex sheet. He then presents some results of flow visualisation studies made using oil, smoke, surface tufts and tuft grid techniques and discusses observed flow patterns with particular reference to various vortices formed at high incidences. Reviewer feels that evidence of existence of "secondary part span vortex" is insufficient, but author may have based his conclusions on data not reproduced in his paper. Much work on similar lines has been done in U.K. (see bibliography in "Incompressible aerodynamics," edited by Thwaites, Oxford, 1960].

H. K. Zienkiewicz, England

354. Polhamus, E. C., and Sleeman, W. C., Jr., The rolling moment due to sideslip of swept wings at subsonic and transonic speeds, NASA TN D-209, 81 pp., Feb. 1960.

An analysis has been made of the effects of wing sweep, aspect ratio, taper ratio, and dihedral on the rolling moment due to sideslip of wing-fuselage configurations up to Mach numbers of about 0.95.

New methods have been derived and design charts are presented for estimating the effects of compressiblity and wing geometry. The over-all agreement between estimated and experimental results indicates that the effects of wing aspect ratio, taper ratio, sweep, and dihedral on the rolling moment due to side-slip of wing-fuselage configurations for sideslip angles up to ±5° could be estimated with reasonable accuracy.

From authors' summary by A. N. Petroff, USA

355. Wynn, W. L., An axis system for five and six degree of freedom airplane dynamic problems, *J. Aero/Space Sci.* **27,** 6, 473-474 (Readers' Forum), June 1960.

356. Perkel, H., Tiros I spin stabilization, *Astronautics* **5,** 6, 38-39, 106, June 1960.

357. Baxter, S. D., Liiva, J., and Sewell, R. T., A probability analysis of coincident gust and manoeuvre loads in low-flying aircraft, Nat. Res. Counc., Canada, LR 264, 30 pp., Nov. 1959.

Starting from assumed gust- and maneuvring-load frequency distributions (referring to particular aircraft flying at 350 knots), frequency distribution of loads resulting from superposition is established by electrical simulation method and by aid of statistical theory. Significant coincidence effects show up in both cases, but numerical results are widely different.

It remains unexplained why; reviewer guesses that the arbitrary one-second duration of gust assumption of the "theory" case may have something to do with it. With such large unexplained discrepancies, publication of the report would seem premature; not much can be done with it now. J. H. Greidanus, Holland

358. Jones, D. T., Power spectrum analysis of gust loads on the Comet wing and tailplane, Aero. Res. Counc. Lond. Curr. Pap. 465, 20 pp., 1960.

This report describes an analysis of measurements of normal acceleration and stress recorded on Comet aircraft while flying in continuous turbulence at high and low altitude. It is found that the increments of normal acceleration at the center of gravity and of stress in the wing and tail are affected by resonance, the vibrations of the wing and tail being forced by the turbulence.

From author's summary by R. Plunkett, USA

Vibration and Wave Motion in Fluids

(See also Revs. 22, 68, 186, 195, 196, 277, 285, 321, 322, 349, 472, 473, 483, 507, 528, 532, 551, 556, 557, 566, 568)

Book—359. Stoker, J. J., Water waves, the mathematical theory with applications (Pure and Applied Mathematics Vol. IV), New York, Interscience Publishers, Inc., 1957, xxviii + 567 pp. $12.75.

It would appear that the author has tried to prepare this book in such a fashion as to make a review unnecessary. A thirteen-page introduction describes his purpose and outlines the contents in some detail. A descriptive table of contents (four pages), an extensive bibliography of work done mainly since 1945, and adequate subject and author indexes all aid one in the use of this monograph. Also, the liberal use of good photographs does much to help the reader's motivation and understanding.

The book is reminiscent of the grand style of Rayleigh's "Theory of sound" and Lamb's "Hydrodynamics" in that the author has tried to cover the background and practical concerns of his subject as well as dealing with the mathematical side in a wholly thorough and uncompromising manner. It is designed for the nonspecialist in the field (the reviewer can testify how well Professor Stoker makes his subject appeal to this category) as well as those who will find material of direct interest in their study and research.

The central topic is the behavior of an inviscid, incompressible bounded fluid with a free surface. The topics are divided by the assumptions required to make the equations tractable: small motions and shallow depth; and the division is rather even between these two topics. In the former, he treats free and forced waves in deep water, waves on beaches and diffraction about an obstacle, and ships' waves. In the latter category, the similarity between the long wave equations and those of gas dynamics allow a fruitful exploitation of the method of characteristics and analogies between supersonic aerodynamics and hydraulic and atmospheric applications. There follows an account of the effect of flow resistance to the motion (the only point at which a viscosity enters significantly in the book) and an account of flood prediction in the Ohio and Mississippi rivers. Finally, there is a discussion of some exact solutions of the general equations, most notably the existence of a solitary wave.

The book contains several valuable items of general interest and utility as well. The discussions of energy and group velocity, the method of stationary phase, and the relation between Sommerfeld's radiation condition and the initial value solutions of radiation problems are of first importance for anyone concerned with the phenomenon of wave motion. This book will find its proper place not on the shelves but in the hands of many physicists, mathematicians, and engineers.

R. Lyon, USA

360. Miles, J. W., On the generation of surface waves by turbulent shear flows, *J. Fluid Mech.* **7,** 3, 469–478, Mar. 1960.

A model recently proposed by Phillips [AMR **11**(1958), Rev. 2884] for the generation of water waves by turbulent winds assumes as its essential mechanism the direct action of aerodynamic pressure fluctuations on the surface of the water, neglecting all interaction between air flow and surface wave. This is essentially an "uncoupled" model, in the sense that excitation is assumed to be independent of response. A "coupled" model had been proposed at same time by author [AMR **12**(1959), Rev. 1977], based essentially on the interaction between mean air flow and surface wave assuming excitation to be proportional to response; the model finds its antecedants in classical problems of hydrodynamic stability, as Kelvin-Helmholtz and Jeffreys theories. Giving due consideration to Phillips' outstanding contribution, author develops here a model that tries to combine the two mechanisms. The response $\eta(x,t)$ of the free surface to a pressure distribution $p_0(x,t) + p_1(x,t)$ is considered, where p_0 denotes a prescribed distribution and p_1 is linearly proportional to η_t. Attention is focused on complementary solutions of the equation of motion for small disturbances, expressed in the form $\eta(x,t) = a(t)e^{ik(x-ct)}$, where $a(t)$ is a slowly varying function of time; the solutions correspond to surface waves excited by convected pressure $p_0(x,t)$, which is also assumed to be a slowly varying, nearly periodic function of the form $f(t)e^{ik(x-Vt)}$. These waves are in a resonance state, having wave speeds c approximating the convection speed V.

The analysis is then two-dimensionally developed to consider the response of the free surface to a random pressure p_0, assuming for it the stochastic form supposed by Phillips with the aid of Fourier-Stieltjes integrals.

Following Phillips, the "principal stage" in the development of surface waves under random pressure is taken into account; for this stage only the growth of the longer gravity waves need be considered, the relatively short waves that influence the wind profile having achieved a statistical equilibrium. The amplitude spectrum $\Phi(\mathbf{k},t)$, in which $\mathbf{k}$ is the vector wave number, is calculated in the form $(2\rho_w^2 c^2)(2m)^{-1}(e^{2mt}-1)\pi(\mathbf{k},0)\theta(\mathbf{k},c\sec\alpha - U)$, where π is the pressure spectrum, θ is the integral time-scale of the pressure fluctuations, as defined by Phillips, and α is the travel angle of a two-dimensional disturbance with respect to the convection speed $U(\mathbf{k}) = V/\cos\alpha$ for the pressure fluctuation.

From this formula author concludes that the relative importance of energy transfers as direct action of pressure fluctuations and as interaction between surface wave and mean flow depends on the size of mt relative to unity, $m \ll 1$ being proportional to the fractional increase in mean energy per radian cycle. An expression for the energy transfer from the mean flow in terms of a Reynolds stress is finally developed; this enables author to evaluate possible values of the function $F(t,m)$ contained in above formula, starting from data quoted by Sverdrup and Munk and referred to by i Phillips.

The conclusion arises that energy transfer associated with interaction between wave surface and air flow may increase the total energy transfer by an order of magnitude, at least under supposed conditions for which nonlinear effects are neglected.

Reviewer is of the opinion that the effort to include shearing flow effects is a valuable improvement of the more simplified Phillips' model, but that a thorough evaluation of the importance of these effects needs a clearer insight into physical and numerical data of the problem.

A. Ghetti, Italy

361. Scholer, H. A., Long period standing waves in harbours, *Instn. Engrs., Australia,* CE **2** (*Civ. Engng. Trans.*) 1, 14–24, Mar. 1960.

Author discusses the characteristics and problems relating to long period standing waves in harbors and proposes two methods for determining the pattern of these waves. Resonant conditions within the harbor are studied for the condition of oscillations at the harbor entrance due to long waves in the adjoining ocean. First method is that of an electrical analog model. The scale relations are derived and the values of the electrical components are shown to be of practical size. This analysis is similar to that of Ishiguno [*Phil. Trans. Roy. Soc. Lond.* (*A*) **251**, no. 996, Mar. 19, 1959] who extends analysis to include effect of friction, discusses error due to finite mesh size, and presents certain practical techniques relating to the analysis.

The second method for use on high-speed digital computers proposes solution of the equation for surface elevation using statistical sampling techniques, an application of the Monte Carlo method. Author has generalized a method by Wasow [*Nat. Bur. Stands., J. Res.* **46**, no. 1, Jan. 1951] for solution of the equation $U_{xx} + U_{yy} + g(x,y)U = 0$. Author notes that the electrical analog model has the advantage of yielding responses to complex forcing functions directly whereas the Monte Carlo method requires superposing separate solutions for the harmonics of the excitation. Also analog method has advantage of rapidly scanning solutions for possible resonant conditions or other effects.

H. G. Farmer, Jr., USA

362. Khaskind, M. D., The radiation and diffraction of surface waves from a vertically floating plate, *Appl. Math. Mech.* (*Prikl.*

Mat. Mekh.) **23**, 3, 770–783, 1959. (Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y.)

This is an extension of a previous study by the author in which he determined pressure of waves against a rigid barrier. In present case the expressions are developed for the forces and moments exerted on a massless plate floating vertically in the water under the action of a regular system of traveling waves. Values of generalized damping and mass coupling coefficients are obtained for the resulting horizontal and rotational motion of the plate. The presentation is highly mathematical and is developed as an idealization of a rolling ship. F. E. Reed, USA

363. Mkhitaryan, A. M., A quantitative analysis of a discontinuous solution of the problem on the determination of the characteristics of a steady train of waves in a rapid current (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Matem. Nauk* **11**, 1, 47–66, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4995.

The paper is devoted to the investigation of the flow of an ideal liquid in a rapid current. Within the limits of the hypothesis for shoal water this motion can be described by the following system of differential equations

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + g\frac{\partial h}{\partial x} = gi$$
$$\frac{\partial h}{\partial t} + \frac{\partial}{\partial x}(uh) = 0 \qquad [1]$$

where u is the velocity along the line of the bottom, h the depth of the liquid, i the angle of slope of the bottom. It is obvious that system [1] cannot have a solution independently of time and periodicity by x. Nevertheless such types of flow can be observed in a rapid current. It follows that to explain them account has to be taken of the viscosity. This the author does by Chezy's phenomenological method while adding to the right-hand side of the first equation the item $-k^2u^2/4h$, where k is some experimental coefficient. In its dimensionless form and in a system of coordinates linked with the rolling waves system, [1] takes the form of

$$\frac{du}{d\zeta} = \frac{i(u-1)(1-\xi^2u^2/4h)}{(u-1)^2-h}$$
$$\frac{dh}{d\zeta} = \frac{ih(1-\xi^2u^2/4h}{(u-1)^2-h} \qquad [2]$$

Here u and h are the dimensionless velocity and depth respectively, ζ is a dimensionless distance, i and ξ are constants. It was established by Dressler [R. Dressler, *Commun. Pure Appl. Math.* **2**, 1949] and Thomas [H. Thomas, "Propagation of waves in steep channels," Proc. Hydr. Conf., Iowa, 1940] that system [2] has no discontinuous periodic solutions.

The basic substance of the present paper is the method developed by means of which the author succeeds in finding the discontinuous periodic solutions for system [2]. System [2] is merged with the equation

$$\frac{dh}{d\zeta} = -\frac{ih[1-\xi^2(h-q)^2/4h^3]}{q^2/h^2-h} \qquad [3]$$

where q is the discharge. With a determined correlation between q and $\xi q = q_0(\xi)$ the numerator and the multiplicand of equation [3] have a common root h_0. Reducing this to $(h-h_0)$ the author obtains the equation

$$\frac{dh}{d\zeta} = i\frac{h^2+h(h_0-\frac{1}{4}\xi^2)+\frac{1}{4}h_0^2\xi^2}{h^2+hh_0+h_0^2} \qquad [4]$$

which is integrated in the closed form

$$h = h^*(\zeta) \text{ and } h_0 = h^*(0) \qquad [5]$$

Function $h(\zeta)$ is continuous in the region $\zeta = 0$. The discontinuous solution has to satisfy three conditions on the line of disruption: (1) equality of mass, (2) equality of energy, and (3) equality of impulses. It was found that condition (2) is fulfilled automatically. Condition (1) is satisfied by selecting for the discharge $q = q_0(\xi)$. Condition (3) permits setting up the magnitude of the jump or, what comes to the same thing, the length of the wave λ. The obtained periodic solution is reformed in the following manner: in the space $[-\lambda/2, \lambda/2]$ solution [5] is set up. At its right-hand end (downstream) is set off downward the magnitude of the jump Δh, and to this point, by means of a parallel set-off, a transfer is made of the left-hand end of the solution set up in the space $[-\lambda/2, \lambda/2]$. In analogous fashion a magnitude Δh is set off at the left-hand end of the space, upward and so on. The author in this manner demonstrates the reality of periodic discontinuous solutions which satisfy the dynamic conditions for the jump; here it is shown as well that there is a well-defined relationship between the magnitude of the jump, the length of the wave and the discharge. With this result, the author carries out a very detailed analysis of the properties of the flow in a rapid current and formulates a number of deductions characterizing these flows.

N. N. Moiseev

Courtesy Referativnyi Zhurnal, USSR

364. Brobikov, I. S., The derivation of a generalized function for the propagation of the heights of waves on the surface of a heavy liquid (in Russian), *Trudi Gos. Okeanogr. In-ta* no. 42, 105–114, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4999.

Visual and semi-instrumental means for estimating the dimensions of wind waves come under criticism and also some methods for the study of wave action with the aid of stereophotography. The best method is acknowledged to be the recording of waves with the aid of the wave-graph. Attention is drawn to the important role played by statistical methods in the investigation of the process of wind-wave formation. A brief description is given of the methods for deriving empirical functions for the distribution of wave elements. A theoretical deduction is put forward for the function of distribution of the amplitudes of wind-waves. The oscillating motion resulting from wind action is presented in the form of the sum-total of a large number of simple sinusoidal waves with different rates of propagation. After making elementary conversions the resulting oscillation U is recorded in the form of

$$U = q\cos[(x - c_0 t) - \theta t]$$

where

$$q = \sqrt{\alpha^2+\beta^2},\ \tan\theta = \frac{\beta}{\alpha}$$
$$\alpha = \sum_{i=1}^{n} a\cos c_i t,\quad \beta = \sum_{i=1}^{n} a\sin c_i t$$

Here c_i represents random divergencies of phase velocities of elementary waves from the mean value of phase velocity c_0. It is demonstrated, by using Lyapunov's boundary theorem, that the random magnitudes α and β obey one and the same normal principle of propagation with a dispersion σ. The author derives a function for the distribution of the amplitude q of the resulting oscillation on the assumption that there is a statistical linkage with the coefficient of correlation R between the random magnitudes α and β. The obtained principle of propagation has the form of

$$F(r) = \exp\left[-\frac{r^2}{2\sigma^2(1-R^2)}\right]\left\{I_0\left(\frac{r^2R}{2\sigma^2(1-R^2)}\right) + 2\sum_{s=1}^{\infty} I_s\left(\frac{r^2R}{2\sigma^2(1-R^2)}\right)\left(\frac{\sqrt{1-R^2}-1}{R}\right)^s\right\}$$

where F is the probability that amplitude q shall be greater than magnitude r, while I_s is Bessel's function with the number s.

Yu. M. Krylov

Courtesy Referativnyi Zhurnal, USSR

365. Grosch, C. E., Ward, L. W., and Lukasik, S. J., Viscous dissipation of shallow water waves, *Physics of Fluid* **3,** 3, 477–479 (Letters to the Editor), May/June 1960.

366. Chu, W.-H., Sloshing of liquids in cylindrical tanks of elliptic cross section, *ARS J.* **30,** 4, 360–363 (Tech. Notes), Apr. 1960.

"By application of potential theory, the forces and moments acting on the tank are determined for the case of translational and rotational excitation along or about the major and minor axes of the cross section, and expressions for the resonant frequencies are found in terms of the roots of the derivatives of modified Mathieu functions. The lowest few resonant frequency parameters, as computed from those expressions, are compared with those of a circular cylinder having the same cross-sectional area." (From author's summary)

Numerical results are given for the cases $(a - b)/(a + b)$ equal to 0, 0.01 and 0.05. (a and b are major and minor semi-axes.) The heading of table Ib appears to contain an important but obvious misprint. A. H. Armstrong, England

367. Howe, J. T., and Martin, E. D., Gas dynamics of an inflated sphere striking a surface, NASA TN D-315, 49 pp., Apr. 1960.

A method for predicting the motion of an inflated sphere striking a hard surface has been developed in which the effect of the wave structure in the inflating gas is considered. The method predicts maximum acceleration, the velocity during impact, and the space-time trajectory of the top of the skin. The effects of the presence of an atmosphere are considered. The required size of a sphere that will not exceed a specified allowable acceleration is determined. Results of 52 examples are presented covering a wide range of initial conditions.

From authors' summary by M. M. Stanisici, USA

368. Martin, E. D., and Howe, J. T., An analysis of the impact motion of an inflated sphere landing vehicle, NASA TN D-314, 45 pp., Apr. 1960.

An inflated sphere landing vehicle is described. The motion of the vehicle during impact on a hard surface is analyzed on the assumption that the inelastic, but flexible, skin maintains a truncated spherical shape. The approximation is made that the pressure of the gas in the vehicle is given by the isentropic pressure due simply to the volume change. The implications of this approximation and its validity are discussed. From the analysis are obtained the requirements and capabilities of the system and curves describing the motion.

From authors' summary by M. M. Stanisic, USA

369. Burger, A. P., and van der Lingen, T. W., The damping effect of distributed and concentrated resistances on small perturbations in a uniform flow, *Quart. J. Mech. Appl. Math.* **13,** 1, 40–48, Feb. 1960.

Effect of a distributed quadratic damping on small two-dimensional harmonic perturbations of a uniform incompressible flow is analyzed. Solution is obtained for the damping factor. Solution simplifies in the cases of widely distributed and concentrated damping. These solutions have applications to the damping effect of flat plate heaters used in blow-down tunnels and gauze wire screens respectively. Good agreement is found between theoretical solution for a concentrated resistance and experiments on gauze screens.

From authors' summary by J. N. Hunt, England

370. Mackie, A. G., and Weir, D. G., The propagation of shock waves of constant strength, *Proc. Camb. Phil. Soc.* **56,** 1, 64–74, Jan. 1960.

The conditions necessary for the propagation of a *constant strength* plane shock wave through a gas in one-dimensional unsteady motion are examined. Except for the constant entropy jump at the shock, the flow is assumed isentropic throughout. Two problems are investigated. The first, treated only very briefly, is the passage of a shock through a simple centered expansion wave. The second problem, treated in more detail, is the passage of a shock through a region of gas initially at rest and having a prescribed density variation. Although the analysis, which involves the solution of a Cauchy problem with initial data prescribed at the back of the shock, is quite nice, the problems treated are academic and will not be of much interest to engineers.

L. Talbot, USA

371. Moore, F. K., and Curtis, J. T., Weak, nonequilibrium, diffusive waves in a dissociated gas, Proc. Heat Transf. Fluid Mech. Inst., Stanford, Calif., June 15–17, 1960; Stanford Univ., 1960, 164–178.

Purpose of this theoretical study is to deal with a relatively simple problem of viscous wave generation in a gas subject to nonequilibrium effects. This might find application, for example, in hypersonic boundary-layer theory.

A semi-infinite region filled with a diatomic gas at rest, which is excited to some equilibrium level of dissociation or vibrational excitation, is considered. The boundary of this region is considered to be a plane material surface in contact with the gas, and at a temperature equal to that of the gas. Then the temperature of the surface is disturbed, as a function of time, sending into the gas a thermochemical diffusive wave in which the gas may or may not be in equilibrium, and which will be effected by catalycity of the surface. Completely linearized, or weak, disturbances are assumed. Lewis and Prandtl numbers are assumed as unity. The effects of two specific types of disturbance are studied: wall temperature varying exponentially with time, and wall temperature undergoing a step-function in time. The interplay between reaction rate and surface catalycity is particularly illustrated.

M. Morduchow, USA

372. Novozhilov, V. V., On the displacement of an absolutely rigid body under the action of an acoustic pressure wave, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23,** 4, 1138–1142, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

The motion of a rigid body, free of supports, that is immersed in an infinite liquid in which a pressure wave is propagating is studied. The total pressure impulse of the wave is assumed to be finite. The problem is solved within the acoustic approximation. It is proven that the displacement of the body tends to some limit as time goes to infinity. This final displacement is found for a finite pressure impulse. The problem is solved for a body having two axes of symmetry, but the results may be generalized to arbitrary shapes. The body will then experience a motion along all three coordinate axes in addition to performing rotations around the axes. The problem is solved in terms of "coefficients of additional mass." M. I. Yarymovych, USA

373. Cox, M., and Bayley, F. J., Effect of flow pulsations on the drag of baffles in pipes, *J. Mech. Engng. Sci., Lond.* **2,** 1, 16–24, Mar. 1960.

An experimental study was made of the basic configuration of a ramjet with flame-stabilizing baffles. The findings are that the baffle loss determined from a non-burning (a cold) test is consistent with results obtained from combustion tests when significant pulsation occurs in the combustion tests; however, pressure losses may be many times higher without pulsation. Satisfactory correlation of cool and combustion tests is obtained when all experiments are performed at subsonic conditions; highest inlet Mach number tested was 0.34. Application of the present test results to ramjet design is therefore limited. S. L. Soo, USA

374. Csanady, G. T., An approximate equation for the "choke-line" of a compressor, *J. Aero/Space Sci.* **27,** 8, p. 637 (Readers' Forum), Aug. 1960.

Fluid Machinery

(See also Revs. 63, 64, 186, 297, 311, 327, 374, 390, 558)

375. Oplatka, G., Design of feedwater tanks and piping in steam power stations, *Brown Boveri Rev.* **46,** 7, 385–394, July 1959.

Dimensioning and arrangement of feedwater tanks and piping for steam power plants is discussed. Conditions leading to cavitation in feedwater pumps in event of sudden removal of load from turbines is analyzed and conclusions regarding practical application of the results are given. The article presumes that readers have knowledge of power station systems, and gives only brief reference to other papers on this subject.

D. W. Appel, USA

376. Shal'nev, K. K., The influence of the form of the frontal edge of a blade on cavitation and the work of a hydroturbine (in Russian), *Trudī Vses. Nauk. In-ta Gidromashinostr.* no. 21, 57–75, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5025.

Questions are investigated dealing with the choice of the most rational forms to be adopted for the faces of blades in the working wheels of variable-pitch bladed hydroturbines. Different variants of the form of the profile of the face are examined from the point of view of their efficiency in regard to minimizing cavitational appearance and in regard to their influence on the k.p.d. (efficiency) of the turbine. It was shown that a slot not fitted with a diffuser and with a rounded inlet edge is the best in relation to minimizing cavitational phenomena, but gives rise to some increase in leakage and, as a consequence, a drop in the k.p.d. (efficiency). Curves are given for the coefficients of consumption and the distribution of pressure along the length of the slot in relation to the cavitation coefficient in the slot. An example is given of damage due to cavitation on one of the full-scale turbines, and the fact is stressed that because of the rounded inlet edges of the faces of the blades it became possible to reduce appreciably the wear due to cavitation and to get it down to the minimum, the required work having been done during the reconditioning of the machine. Results are also given of investigations with models for the determination of the influence of the form of the face's edge on the energetic and cavitation characteristics of turbines, which show that the rounding of the edges causes in some zones a measure of loss of efficiency (k.p.d.) whereby the cavitation coefficients undergo an appreciable fall. The differences in the forms of cavitation appearing in the slot are referred to and a classification is drawn up for them. Formulas are put forward for the coefficients of cavitation, each form of cavitation being dealt with separately. An example is furnished for the calculations of cavitation coefficients for full-scale turbines.

M. F. Gubin

Courtesy Referativnyi Zhurnal, USSR

377. Bernshtein, L. B., Efficiency increase of low-head power plants (in Russian), *Gidrotekh. Stroit.* **28,** 1, 33–42, Jan. 1959.

In low-head power plant author suggests the application of submerged bulb-type turbine-generator unit developed in tidal power plants and operating both as a pump and a turbine in either direction. Relying upon French and German papers author reviews the results and problems of Castet and St. Malo power units in detail. Data are given in connection with the expected construction and energy advantages. The article ends with a brief summary of the results achieved in USSR relative to horizontal turbines.

A. Verba, Hungary

378. Titov, I. A., The designing of propeller screws with sections for the blades conforming to aviation practice (in Russian), *Sudostroenie* no. 3, 10–17, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5017.

Paper gives the results of systematic tests carried out in an A. V. Krylov cavitation tube of the TsNII type on several sets of models of four-bladed propeller screws with sections for the blades conforming with aviation usage. These tests were planned to verify the reliability of previously carried out experiments with the same type of models of bladed screws in the Troost and Holland experimental tank. In addition to the above, the experiments had the objective of a comprehensive study of the influence of the relative thickness of the blades of the propeller screws, with sections for the blades conforming with aviation practice, on their hydrodynamic characteristics, and also of the influence of the basic parameters of the propeller screws of the type being investigated on the moment of onset of cavitation, in so far as both these matters were not investigated by Troost. Six series in all of four-bladed models of propeller screws were tested, with values for the disk relation of 0.35, 0.58, and 0.75, the conditioned relative thickness on the screw's axis of 0.04 and 0.06, and the relative diameter of the hub of 0.20. Graphs are supplied for the delineation of the theoretical drawing of the blade and also for the results of the tests, presented in the usual form of the relation of the pressure coefficient to the relative pitch of the screw. In addition, a diagram is given for the determination of the moment of disappearance of the second stage of cavitation in relation to the disk ratio, the specific loading and the depth of immersion of the propeller screw. The paper concludes with an example of the calculations illustrating the utilization of the published graphs and diagrams, and with the formulation of conclusions obtained on the basis of an analysis of the tests carried out.

I. V. Girs

Courtesy Referativnyi Zhurnal, USSR

Flow and Flight Test Techniques and Measurements

(See also Revs. 227, 278, 297, 302, 313, 315, 343, 347, 349, 369, 482, 491, 507, 564)

379. Maude, A. D., Theoretical evaluation of capillary viscometers for the measurement of the viscosity of suspensions of spheres, *Brit. J. Appl. Phys.* **10,** 8, 371–376, Aug. 1959.

Paper proposes a theoretical modification of Einstein's formula for the influence on apparent viscosity of particles suspended in a liquid when the viscosity is measured by means of a capillary tube. The single parameter of relative particle size is employed to express the effect of parabolic velocity profile and, also, disturbed concentration, on the viscosity. Author states that only first-order concentration factor is effective. But Professor Andrade says that this does not hold for volume concentrations above 0.2%. (See "Viscosity and plasticity" by E. N. da C. Andrade, Royal Society Lectures published by the Chemical Publishing Co., Inc., New York, New York.)

Author concludes that additional factors such as form of tube entrance are needed to bring theory into acceptable agreement with observation.

W. J. Moreland, USA

380. Mamedzade, Yu. I., The discharge of viscous liquids at variable pressures (in Azerb.), *Azerb. Neft. Kh-vo* no. 8, 13–16, 1953; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5033.

The results are given in tabular form and a series of curves of experiments carried out to determine the coefficients of discharge from orifices of viscous liquids. The viscosity was changed in the various experiments (from $\nu = 0.27$ to 26.6 cm²/sec), also the

pressure (0.2 to 1.8 m) and the form of the orifices (round, rectangular, square, triangular and cruciform).

I. A. Charnyi
Courtesy Referativnyi Zhurnal, USSR

381. Herning, Fr., and Bellenberg, H., New experiments with standard orifices (in German), *Brennstoff-Wärme-Kraft* **12**, 3, 89–96, Mar. 1960.

In order to examine how far the discharge coefficient depends on the shape of the velocity profile in the up-stream flow, experiments were carried out with water in a test rig with diameters of 100 and 150 mm, with diffusors and with a narrowing cone installed ahead of the orifice. It is shown that there are definite relationships between velocity profile and discharge coefficient. However the results are not sufficient for deriving quantitative relationships.

In order to examine the discharge coefficient with pressure tappings at different distances before and after the orifice, experiments were carried out with air as flow medium, in a smooth brass tube of 76 mm diameter and in a rough steel tube of 79 mm diameter. The results of the measurements make it possible to obtain the correction factor for each pressure tapping deviating from the standards. For "vena-contracta" tapping as well as for flange taps these correction factors are compared with the discharge coefficients obtained by calculation from the German standard values. The agreement is good. For orifices with which standard pressure tapping is not possible a simplified method of vena contracta tapping is proposed. From authors' summary

382. Kolupaila, S., Water measurements in hydraulic structures and power plants (in French and English), *Houille Blanche* **15**, 4, 344–363, June 1960.

383. Zheleznyakov, G. V., The location of average velocity on the vertical free water flow, *Measurement Techniques* no. 6, 466–468, June 1960. (Translation of *Izmeritel'naya Tekhnika* no. 6, 58–59, June 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

384. Kivilis, S. S., Discharge coefficients of diaphragms and nozzles, *Measurement Techniques* no. 6, 469–473, June 1960. (Translation of *Izmeritel'naya Tekhnika* no. 6, 60–63, June 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

385. Karpov, R. G., Measurements of pressures defined by the relation $P = P_0 + p(t)$ for $p(t) \ll P_0$, *Measurement Techniques* no. 6, 416–420, June 1960. (Translation of *Izmeritel'naya Tekhnika* no. 6, 21–24, June 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

386. Zhokhovskii, M. K., Experimental determination of errors in piston manometers at high pressures, *Measurement Techniques* no. 7, 505–509, June 1960. (Translation of *Izmeritel'naya Tekhnika* no. 7, 11–13, July 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

387. Brombacher, W. G., Johnson, D. P., and Cross, J. L., Mercury barometers and manometers, Nat. Bur. Stands. Mono. no. 8, 59 pp., May 1960.

The various designs of mercury barometers and manometers are briefly described, with a more extended discussion of the various design elements which may affect the achievable accuracy. Sources of error in measuring pressures are described in considerable detail, particularly for portable instruments, including scale, temperature, gravity, capillarity, vacuum errors and return gas column. Methods of minimizing those errors and of making the corrections, including extensive tables, are presented. Standard conditions are defined and the pertinent properties of mercury given. The paper contains 65 literature references.

From authors' summary

388. Richter, W., Interferometer with large mirrors for optical flow investigations (in German), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1958, 105–117.

Author presents general considerations on interferometer design for aerodynamic purposes. He describes design and operation of a Mach-Zehnder instrument with a plate diameter of 340 mm. In order to make better use of these large plates a rhombic arrangement instead of the usual rectangular one has been chosen.

L. J. F. Broer, Holland

389. Jenkins, D. C., and Booker, J. D., A photographic study of the impact between water drops and a surface moving at high speed, Aero. Res. Counc. Lond. Curr. Pap. 501, 18 pp., 1960.

The normal impact between 2-mm diameter water drops and a smooth, hard, surface moving at 1000 ft/sec has been studied photographically and the results discussed. The speed of the radial flow resulting from the impact has been measured and an estimate made of the corresponding pressure existing between the drop and the surface.

The case of impact of drops on rough, deformable and inclined surfaces has also been briefly considered.

From authors' summary

390. Martinot-Lagarde, A., Problems posed by experimentation in wind tunnels (in French), Publ. Scient. Tech. Min. Air, France no. 353, 104 pp., 1959.

Paper is a discussion of scaling rules and similarity parameters used in tunnel design and model testing with low-speed horizontal and vertical wind tunnels. This bulletin is primarily of interest to French-speaking students beginning a study of aerodynamics. Transonic flow is discussed briefly, but without reference to the problem of shock waves or the slotted wall used so successfully in recent years. Of most interest to this reviewer is the fine description of the vertical spin tunnel at the Institute of Fluid Mechanics in Lille. W. C. Griffith, USA

391. Bull, G. V., Aeronautical studies in the aeroballistics range (in English), Jahrbuch Wissenschaft. Gesellsch. Luftfahrt, 1957, 247–260.

Paper presents the technique of the aeroballistics range in aerophysics research. Guns are used to launch the model through the range proper at the desired Mach number. The range is instrumented to permit the observation of the model flight path and of the flow field. In this way aeronautical stability derivatives and qualitative data on the aerodynamic flow can be determined.

Theoretical and practical aspects of aeronautical stability, performance and control problems are briefly discussed and some illustrative experimental studies (such as cruciform wing-body, wing-body-tail, pure wing planforms) performed at C.A.R.D.E. (Canadian Armament Research and Development Establishment) are presented. M. I. Ionescu, Roumania

392. Ganzer, V. M., and Rao, W. H., Jr., An experimental investigation of the effect of wind tunnel walls on the aerodynamic performance of a helicopter rotor, NASA TN D-415, 35 pp., May 1960.

Experimental tests were made to determine the range of advance ratio and blade angle in which wind-tunnel wall corrections as developed for wings might be used for helicopter rotors. Lift and drag coefficient data were corrected by standard wing-type wall corrections using the full span of the rotor as the vortex span and the area of the rotor disk as the wing area. Data from three test section sizes were compared to determine at which blade angles

and advance ratios the wind-tunnel wall corrections gave satisfactory agreement. From authors' summary

393. Parlett, L. P., Wind-tunnel investigation of a small-scale model of an aerial vehicle supported by ducted fans, NASA TN D-377, 24 pp., May 1960.

The longitudinal-stability and pitching-moment characteristics and the power requirements of a simplified model of an aerial vehicle supported by ducted fans have been investigated. The model had two ducted fans, both fixed with respect to the airframe with their axes of revolution vertical for hovering flight. Tests on the basic model in the tandem and side-by-side configurations indicated that the pitching moment and tilt angle required for trim at forward speeds were undesirably large. Turning vanes placed in the slipstream of the forward duct of the tandem configuration reduced both the pitching moment and tilt angle, but probably increased the power required.

From author's summary

394. Yaggy, P. F., and Rogallo, V. L., A wind-tunnel investigation of three propellers through an angle-of-attack range from 0° to 85°, NASA TN D-318, 81 pp., May 1960.

Two of the propellers were rigid and one had flapping hinges. The range of advance ratios included those anticipated for certain VTOL/STOL aircraft in take-off, transition, and landing. Measurements were obtained of power input to the propellers and the propeller forces and moments. From authors' summary

395. Greif, R. K., Kelly, M. W., and Tolhurst, W. H., Jr., Wind-tunnel tests of a circular wing with an annular nozzle in proximity to the ground, NASA TN D-317, 37 pp., May 1960.

Exploratory tests were conducted to determine the effects of forward speed and ground proximity on the vertical thrust of an annular nozzle exhausting from the lower surface of a thin circular wing. Lift, drag, and pitching-moment data are presented with nozzle airflow data over ranges of altitude, nozzle pressure ratio, free-stream dynamic pressure, and wing angle of attack. Pressure distributions on the wing lower surface and on the ground are also included. From authors' summary

396. Kelly, M. W., Greif, R. K., and Tolhurst, W. H., Jr., Full-scale wind-tunnel tests of a swept-wing airplane with a cascade-type thrust reverser, NASA TN D-311, 31 pp., Apr. 1960.

This report presents results of a full-scale wind-tunnel investigation of an F-100F airplane equipped with a cascade-type thrust reverser. Longitudinal and lateral-directional stability and control data are presented for several thrust reverser configurations.

From authors' summary

397. Brundin, C. L., Talbot, L., and Sherman, F. S., Flow studies in an arc-heated low density supersonic wind tunnel, Univ. Calif., Inst. Engng. Res. TR HE-150-181 (Contract AF 49 (638)-502), 39 pp., Apr. 1960.

A series of experiments was carried out to evaluate several methods for determining the properties of the flow produced in a supersonic low-density arc-heated wind tunnel, using argon as the test gas. These experiments included stagnation point Langmuir probe and heat-transfer measurements, impact pressure surveys, and some qualitative spectroscopic studies. A typical set of operating conditions indicated by the measurements were $M \cong 6$, $p_{static} \cong 1$ mm Hg in the free jet, centerline stagnation temperature $T_t \cong 5000°$ K, and approximately 0.2% ionization with an electron temperature of about 2×10^4 °K. From authors' summary

398. Miles, C. J. W., and Fox, Mrs. R. C., Tests on a 1/36 scale model of the Vickers M. T. 1000 in the compressed air tunnel, N. P. L., Aero. Res. Counc. Lond. Curr. Pap. 485, 23 pp., 1960.

The report describes measurements of lift, drag and pitching moments on a 1/36 scale model, up to a Reynolds number of 7 millions. The experiments covered the effect of flaps (30° and 50°), dive brakes (30° and 50°) and of two tail planes of different span at two angles of incidence (+2° and −2°) relative to the wing.

The highest value of $C_{L_{max}}$ measured was 1.61 (with 50° flaps). Scale effect on downwash at the tail apparently disappears above $R = 3 \times 10^6$. From authors' summary

399. Bennett, A. S., Comparative high speed tunnel tests of an N. A. C. A. submerged and a scoop type air intake, Aero. Res. Lab., Melbourne, Austral. Rep. A. 117, 102 pp., Sept. 1959.

The performance of two intakes, one an NACA submerged-type and the other a scoop-type intake, has been investigated in wind tunnel tests up to a Mach number of 0.90. For both intakes, engine face total and static pressure recoveries as well as engine face velocity distributions were obtained with the addition, for the submerged unit, of intake ramp face velocity distributions.

Within the range of the tests, which covered engine face velocities from 0.2 to 0.7 times free stream, Mach numbers up to 0.90 and fuselage incidences of 0° and +4°, it was found that:

(1) The behavior of the scoop intake under all conditions of Mach number, incidence and engine face velocity was very good and losses, at flight Reynolds numbers, could be expected not to exceed 5% of free-stream total pressure ($\Delta H/H_0 < 0.05$).

(2) Up to Mach numbers of about 0.5 both intakes performed equally well in both pressure recovery and engine face velocity distribution.

(3) In the Mach number range 0.5 to 0.7, the losses for the submerged intake gradually increased till at $M_0 = 0.7$ they were generally about twice that for the scoop intake.

(4) At speeds above $M_0 = 0.7$ the losses for the submerged intake increased rapidly while those for the scoop unit remained quite small. For example, at a Mach number of 0.8, a fuselage incidence of 0° and a mean engine velocity of 0.5 times free stream, the total pressure losses were $\Delta H/H_0 = 0.127$ for the submerged intake and $\Delta H/H_0 = 0.027$ for the scoop intake.

(5) For the submerged intake, measured pressure distributions indicated that the increase in losses above a Mach number of about 0.7, and the associated deterioration in engine face velocity distribution, was due to shock-induced separations on the ramp face and upper lip of the intake. These distributions also indicated a definite change in the vortices, shed by the intake, at these speeds.

Comparisons have also been made with data obtained in the low-speed tunnel for both intakes and with a small amount of information available for the submerged intake in flight.

From author's summary

400. Groenig, H., Measurements of the diffusion of electrons out of strong shock waves, AFOSR TR 59-160 (Technical Univ., Institut fuer Mechanik, Aachen, Germany), 42 pp., June 1959.

Measurements by means of a gas discharge probe in a hydrogen-argon shock tube at Mach numbers between 5 and 10. The results indicate an increase in conductivity of the argon in a region of a few centimeters in front of the shock. This effect is interpreted as due to diffusion of electrons from the ionized gas behind the shock. Magnitude and pressure and temperature dependence of the diffusion coefficient of electrons in argon derived from the conductivity profiles on this assumption are satisfactory. Under certain circumstances the discharge breaks down to a glow discharge when the shock is still 10 to 30 cm away. It is made plausible that this is due to ultraviolet radiation emitted by the hot gas behind the shock. L. J. F. Broer, Holland

401. Gundersen, R., The piston-driven shock, *J. Aero/Space Sci.* **27,** 6, 467-468 (Readers' Forum), June 1960.

402. Cartmel, J. A. B., Techniques used in a programme of free flight aerodynamic trials, Austral. Defense Scient. Service, Weapons Research Establishment TN SAD 40, 36 pp., May 1959.

The note presents a discussion of some of the techniques that were used and developed during the course of a program for the free-flight measurement of the aerodynamic derivatives for a related series of wing-body test vehicles.

From author's summary

403. Judd, J. H., and Woodbury, G. E., Free-flight measurements of the transonic drag characteristics of low-fineness-ratio cylinders, including stabilizing plates and flares and varying nose bluntness, NASA TN D-361, 16 pp., May 1960.

Various blunt-nose bodies of revolution of low fineness ratio based on a right circular cylinder of fineness ratio of 2.0 were tested in free flight to determine drag coefficients over a Mach number range from 0.6 to 1.2 and a range of Reynolds numbers per foot from 4.0×10^6 to 8.3×10^6. A single stabilizing plate at the front and rear, a 16.5° conical flare, various nose radii, and 16.5° truncated-cone nose fairings were tested.

From authors' summary

404. Ludi, L. H., and Yeates, J. E., Jr., Flight measurements of the effects of blade out of track on the vibration levels on a tandem rotor helicopter, NASA TN D-364, 26 pp., May 1960.

Some results are presented which show how the vibration level changes because of one blade on the front rotor being out of track for a range of out-of-track values. Measurements of blade out of track relative to a master blade are shown for the front rotor as recorded by an electronic blade tracker. Blade-fuselage clearances for the front and rear rotor were measured during an abrupt maneuver. Calculations which enable the prediction of vibration due to an out-of-track blade in hover are discussed.

From authors' summary

405. Hintze, G., Real-time analysis, new approach in flight testing, *ARS J.* **30,** 5, 500–502 (Tech. Notes), May 1960.

The possibility of increasing the information contents of flight records through controlled exercise of missiles during firing tests is discussed. The discussion is based on a brief description of an experiment which is presently being planned at White Sands Missile Range for the accurate determination of aerodynamic coefficients under controlled and trimmed flight conditions. The best solutions for the analysis equations will be obtained when the exciting fin deflection and the corresponding angle of attack are approximately 90 deg out of phase. This leads to the requirement to exercise the missile with a frequency close to its natural frequency. The basic relations of natural frequency and damping ratio as functions of missile velocity and altitude are derived, and typical trends of natural frequency with altitude for different Mach numbers, as obtained from flight simulation studies, are presented. Firing tests can be made into experiments yielding more information concerning the in-flight component and missile behavior when, through the real-time analysis of flight data, exercises of the missile can be introduced which are adapted to the momentary flight condition.

From author's summary

Thermodynamics

(See also Revs. 232, 305, 375, 455, 479, 483, 486, 487, 526, 542)

Book—406. Jones, J. B., and Hawkins, G. A., Engineering thermodynamics, New York, John Wiley & Sons, Inc., 1960, xviii + 724 pp. $8.50.

This is one of a number of new books on thermodynamics recently published. It differs from most in being written specifically for engineering students and should be viewed more as a textbook than as a work of reference. People slightly remote from thermodynamics may find it a useful addition to their library, however, for use as an occasional refresher on basic principles. The detailed explanation given, especially in the first half of the book, is exhaustive to the border of verbosity but reviewer feels that many students will welcome this. The ground covered by the book has been deliberately restricted in order to force home the first and second laws and some of their corollaries and their application to various systems, including turbines, standard gas power cycles, the steam cycle and refrigeration. A short chapter on the elements of heat transfer is also included. Over seven hundred problems are presented, solutions from basic principles being given, often in appreciable detail. Engineering details are in the main excluded.

G. G. Thurlow, England

407. Chukhrov, V. A., Investigation of an ideal cycle of a gas turbine with a rotor-generator of compressed gas in continuous combustion (RGSG NG) (in Russian), *Nauchno-Tekhn. Inform. Byul. Leningrad Politekhn. In-ta* no. 3, 30–37, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4920.

An investigation is made of the thermal efficiency (k.p.d.) of an ideal cycle of a gas-turbine plant of type RGSG NG, in which the rotor, directly connected with the shaft of the compressor, achieves its rotational movement through the reaction of jets issuing from the nozzles of the combustion chamber, situated around the rotor, while the gas turbine produces efficient work. The process of continuous combustion is replaced for purposes of convenience by a simple supply of heat. An analysis of the relation of the thermal efficiency (k.p.d.) is given; this is expressed through the brought-in stage of enhanced full pressure, of the rotational velocity of the rotor and of the parameters characterizing the flow of gas at the outlet from the combustion chamber.

N. A. Kolokol'tsov

Courtesy Referativnyi Zhurnal, USSR

408. Bulanin, V. I., A method for determining the optimum parameters for gas-turbine plant (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 193, 119–133, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4922.

The problem of determining the maximum efficiency (k.p.d.) of a gas-turbine installation as a function of several variables, part of which are independent and part dependent variables, is solved. A mathematical problem of this nature is easy of solution provided the system of equations for the linkage is capable of solution relative to the dependent variables. If this should be the case the problem merges with the determination of the extreme function of several independent variables. If the system of equations for the linkage is not capable of solution then various artificial methods are resorted to, in particular the known method of Lagrange factors. A case for employing the proposed procedure for determining the optimum parameters is shown to be a double-shaft gas-turbine installation of the open type. For purposes of simplifying the problem a number of assumptions are made; however in this case a great amount of computation work is required, and the obtained system of equations is found in practice to be analytically unsolvable (recourse to graphoanalytical solution of one of the equations is unavoidable).

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

409. Stupochenko, E. V., Dotsenko, B. V., Stakhanov, I. P., and Samuilov, E. V., Method of calculation of the transport coefficients of air at high temperatures, *ARS J.* **30,** 4, 394–402, Apr. 1960. [Translation of **Fiz. Gazodinamika [Physical Gasdynamics],** USSR Acad. Sci., 39–58.]

Paper contains theoretical calculations of viscosity and thermal conductivity of air in the temperature range from 2000 to 8000 K and in the pressure range from 0.001 to 1000 atm. The approximate calculations are based on the assumption that at these high

temperatures air represents a binary mixture of molecular and atomic gas components. The law of intermolecular interaction is expressed in the form of the modified Buckingham potential; the necessary gas kinetic diameters of the atomic nitrogen and oxygen, which were not measured experimentally, are determined by means of an interesting interpolation based on the regularity of the periodic system. Further, the heat conduction in a binary mixture of chemically reacting gases is investigated by methods of the thermodynamics of irreversible processes. The proper calculations of the viscosity of air and the coefficient of heat conduction based on the treatment performed are contained in the reports of the Laboratory for the Physics of Combustion, Power Scientific Research Institute, 1955; the present paper presents only rough results given in graphical form. F. Krupka, Czechoslovakia

410. Samuilov, E. V., Concerning the problem of the influence of internal degrees of freedom of particles on the transport coefficients of a multicomponent mixture of gases, *ARS J.* **30,** 4, 388-393, Apr. 1960. (Translation of **Fiz. Gazodinamika [Physical Gasdynamics]**, USSR Acad. Sci., 59-69.)

To deal with the problem given in the title author uses the probabilities of various types of molecular collisions obtained quantum-mechanically by various investigators and he solves the system of generalized kinetic equations by the Enskog method. The expression obtained for the coefficient of heat conduction is a generalization of a formula of the Eucken type to include the case of a multicomponent mixture of gases and can be used to calculate the heat-conduction coefficients with allowance for arbitrary internal degrees of freedom of molecules. The influence of internal structure on the magnitude of the bulk viscosity is explained by means of the phenomenological theory developed by Mandelshtam and Leontovich. F. Krupka, Czechoslovakia

411. Minkin, Z. M., Calculations for the thermodynamic properties of the gases on the lines of compression and of the widening of the indicator diagram (in Russian), *Energomasbinostroenie* no. 4, 17-19, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4935.

An examination is made of the gas in the cylinder of a diesel engine which is looked upon as a mixture of two components: surplus air and "pure" combustion products. On this basis the author elaborates a unified method of calculation of the heat capacities of the gases on the lines of compression and of the widening of the indicator diagrams. The method described for the computation of the relative quantity of "pure" combustion products is also convenient for the determination of enthalpy, internal energy and the entropy of gases. I. S. Smionov

Courtesy Referativnyi Zhurnal, USSR

412. Faltin, H., New equations for the temperature dependence of specific heats of perfect gases (in German), *Technik* **15,** 9, 592-596, Sept. 1960.

413. Kastner, L. J., and Williams, T. J., Pressurized discharge of liquid from a closed vessel, *J. Mech. Engng. Sci., Lond.* **2,** 1, 29-34, Mar. 1960.

Paper, although general in terms, was apparently inspired mainly by problem of determining minimum size of tank required to hold gas used to maintain pressure on liquid fuel in a rocket chamber (for purpose of fuel flow regulation). Initial pressure and temperature of gas being given, minimum gas volume required to discharge specified liquid volume at given pressure is to be found. Only simple thermodynamic relations are used, but possible range from adiabatic to isothermal conditions is considered. Analysis is first made for ideal gas; then Joule-Thomson effect is introduced, but this effect is not very significant. Various numerical examples are worked out, and some results are given in graphical form. As would be expected, initial pressure of gas (values considered up to 400 atmospheres) is chief factor affecting volume, but heat interchange also has appreciable influence. Paper should be of interest to liquid-fuel rocket designers especially.

C. W. Smith, USA

414. Besseling, J. F., Thermodynamic foundations of the theory of deformation, AFOSR TN 59-871 (Stanford Univ., Dept. Aero. Engng. no. 86), 26 pp., Aug. 1959.

This paper, to be published in the proceedings of the Durand Centennial Conference on Aeronautics and Astronautics held at Stanford University in 1959, presents an interesting treatment of the basic concepts of the thermodynamics of the inelastic deformation of solids. Energy flux and entropy are introduced as fundamental quantities with the mechanical stress concept and equilibrium equations obtained as derived quantities with the aid of the Galilean principle of relativity.

Inelastic deformations are introduced by use of the concept of a natural reference state which is locally accessible by a reversible process. The treatment is restricted to small inelastic strains from the initial state, a restriction which the author states is "a natural one in a theory of deformation where all changes are *a priori* to be defined with respect to an absolute reference state."

J. H. Weiner, USA

415. Veinik, A. I., The thermodynamic theory of elasticity (in Russian), *Dokladi Akad. Nauk BSSR* **1,** 2, 48-51, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2879.

The basis of the theory is an assumption that the supply of energy to the body is accompanied by the weakening of the interatomic and intermolecular linkages. Emanating from this position the author asserts that when the body passes from the liquid to the gaseous state forces of repulsion take the place of forces of attraction. The author puts forward a number of correlations between some of the mechanical and thermal characteristics of matter. V. N. Rozhanskii

Courtesy Referativnyi Zhurnal, USSR

416. Dixon, M. H., An analysis of thermoelectric effects, *J. Amer. Soc. Nav. Engrs.* **72,** 2, 255-269, May 1960.

An interesting review of the technical aspects of thermoelectric effects. In the author's words "It is presented in the hope that it may save others hours of digging and sorting necessary to sort out the facts and theory for a modicum of understanding." It is recommended for those desirous of obtaining a general comprehension of the subject area. G. A. Hawkins, USA

417. Bateman, P. J., Some notes on the possible application of thermoelectric devices to the generation of electric power, Aero. Res. Counc. Lond. Curr. Pap. 499, 16 pp., 1960.

When waste head is available in a convenient form, conversion to useful electrical power should be possible by means of thermoelectric devices which, fabricated from semiconductor materials already developed, should give a power output per unit weight comparable with that of conventional small d c power sources. This can only be realized in practice if installation and construction problems can be overcome, and the effective hot and cold junctions are of the order of 1 cm apart. Efficiencies are, however, so low at present that it is unlikely that thermoelectric devices will be produced for the large-scale production of electrical power. From author's summary

Heat and Mass Transfer

(See also Revs. 19, 24, 61, 286, 292, 311, 324, 330, 331, 338, 343, 371, 413, 457, 483, 485, 510)

418. Eckert, E. R. G., Hartnett, J. P., and Irvine, T. F., Jr., Heat transfer bibliography (in English), *Inter. J. Heat Mass Transfer* **1,** 1, 102-112, June 1960.

419. Gurtin, M. E., On the use of normal coordinates for the solution of lumped parameter transient heat-transfer problems, *J. Aero/Space Sci.* **27,** 5, 357–360, May 1960.

A system is considered in which heat flows through separate branches, which are supposed to be linked at a number of junctions. In order to find the temperatures at the junctions as functions of the time, use is made of the familiar analogy with electric network. The relevant equations can then be presented in a compact form as a linear inhomogeneous matrix equation. An algebraic solution of this equation is found and hence the temperatures are expressed by a closed formula as functions of the time. The coefficients in this formula are obtained by diagonalizing an $r \times r$ matrix whereby the number of junctions is assumed to be $r + 1$.

Author appears to regard the diagonalization of the matrix as a matter of routine. R. Eisenschitz, England

420. Citron, S. J., Heat conduction in a melting slab, *J. Aero/Space Sci.* **27,** 3, 219–228, Mar. 1960.

Author has reconsidered a problem previously treated by Landau [*Quart. Appl. Math.* **VIII,** no. 1, 81–94, 1950; AMR **4**(1951), Rev. 430]; this is the heat-conduction problem in a melting body. Landau formulated this problem for the one-dimensional case and obtained some general properties of any solution by means of an application of Gauss' theorem. The work was then specialized to a material with constant properties and one which was semi-infinite in extent. Landau treated the case of constant heat input and re-cast the entire problem in terms of dimensionless variables which depended upon a single parameter. The solutions were presented in the form of charts and were obtained by means of a digital computer.

The present paper uses the same analytical formulation that was employed by Landau but the solution is obtained in an approximate analytical manner and the calculations can be carried out by means of a desk calculator. Author restricts himself also to the case of constant material properties, but the body is now a finite slab. The first approximation is obtained as the solution of a second-order linear differential equation and subsequent approximations are obtained by iteration; this approximate solution, in conjunction with the solution of a first-order nonlinear differential equation (obtained numerically), then defines the approximate solution to the problem.

This approximate method was applied to two cases: constant heat input and heating due to the descent of a body through the atmosphere. The former case was used to check the approximate results against other solutions and against the known general properties of the nonlinear problem. The agreement is satisfactory, particularly at the higher melting rates. Similar approximations were also carried out for the case of atmospheric heating and some results are again shown in the form of graphs.

F. V. Pohle, USA

421. Klose, W., Heat conduction coefficient of a thin wire (in German), *Z. Naturforsch.* **13a,** 11, 978–985, Nov. 1958.

A mathematical paper in which the thermal conductivity is calculated by means of the Boltzmann equation with a simplified forcing term for the case of an infinitely long cylindrical wire. The approximations are thoroughly discussed.

W. C. Orthwein, USA

422. Grassmann, P., and Straumann, W., An unsteady-state method for the measurement of thermal conductivities of gases and liquids (in German), *Inter. J. Heat Mass Transfer* **1,** 1, 50–54, June 1960.

Authors measure the thermoconductivities of gases and liquids by unsteady-state wire methods. Wire is placed vertically in fluid and heated. Plot of wire surface temperature versus log of time is a straight line, slope of which is used to determine thermoconductivity of fluid. Method depends upon comparing the conductivities of two substances. Change in voltage obtained by heating wires is measured by two similar wheatstone bridges and fed to two mutually perpendicular axis of a recorder. Results obtained were within ±1% accuracy after about 0.1 seconds. After 5 seconds, convection effects were noticed. Method is useful for substances of low viscosity where convection occurrence sets in shortly after heating. Start of convection is detected by change in slope of line drawn by recorder. Authors note various sources of error. J. G. Knudsen, USA

423. Walker, R. E., DeHaas, N., and Westenberg, A. A., New method of measuring gas thermal conductivity, *Physics of Fluids* **3,** 3, 482–483 (Letters to the Editor), May/June 1960)

424. Kuo, C. Y., Iida, H. T., Taylor, J. H., and Kreith, F., Heat transfer in flow through rotating ducts, *ASME Trans.* **82** C (*J. Heat Transfer*), 2, 139–151, May 1960.

The local temperature was measured at three axial locations on the inner surface of a heated horizontal tube 24 in. long with 3-in. I D circular cross section, rotating about its own axis while water flowed axially within it. Tests were also made with a solid coaxial cylindrical core of 2.62-in. O D added—thereby forming an annular duct. This core rotated with the tube. With each of these two configurations, tests were made with the liquid level only partially filling the duct, and also with the duct entirely full. A few tests were made also with the central core replaced with four long radial paddles at 90° intervals peripherally, extending inward from the duct wall about half-way to the axis.

The velocities were relatively low—the axial Reynolds number (based on the I D of the round tube) ranged from 60 to 950. Rotational Reynolds number ($N_{Re,\omega} = D^2\omega/\nu$), ranged from 5000 to 200,000. Results are plotted as Nusselt number versus $N_{Re,\omega}$ with axial velocity as parameter. For the plain tube (i.e. no core, no paddles), both partly full and entirely full, the Nusselt number was roughly proportional to $(N_{Re,\omega})^{\frac{1}{2}}$ for $N_{Re,\omega}$ from 5000 to about 20,000—then remained nearly constant as $N_{Re,\omega}$ rose to about 100,000, then began to rise again with increase of $N_{Re,\omega}$ up to 200,000. Nusselt number also increased with increasing axial Reynolds number, the rate of increase being independent of $N_{Re,\omega}$ for all $N_{Re,\omega}$. No theoretical explanation for the breaks in slope of the curves versus $N_{Re,\omega}$ was found.

For the annular duct, both full and partly full, the shape of the corresponding curves is quite different. For $N_{Re,\omega}$ below about 20,000, the curves are horizontal—i.e. $N_{Re,\omega}$ has no effect. For $N_{Re,\omega}$ from about 20,000 to 80,000, Nusselt number rises about as $(N_{Re,\omega})^{\frac{1}{2}}$. Above $N_{Re,\omega} = 80{,}000$, Nusselt number remains about constant in most cases. These three regions of $N_{Re,\omega}$ are explained in terms of flow patterns observed photographically. Taylor vortices begin as $N_{Re,\omega}$ rises above 20,000.

In both the above pairs of conditions, the partially filled duct gave somewhat higher Nusselt numbers than the corresponding completely filled duct, for the same total mass flow rate axially.

For the partially filled plain tube, the temperature difference was varied and found to produce no change in the heat-transfer coefficient, thus showing negligible effect of free convection phenomena.

The use of paddles showed, surprisingly, a decrease in Nusselt number, compared to the plain tube, for $N_{Re,\omega}$ above 20,000.

R. H. Norris, USA

425. Liebert, C. H., Hatch, J. E., and Grant, R. W., Application of various techniques for determining local heat-transfer coefficients in a rocket engine from transient experimental data, NASA TN D-277, 33 pp., Apr. 1960.

Experiments involve obtaining the thermal history of copper plugs which are inserted in the wall and throat of a solid-wall ammonia-oxygen rocket. Temperature measurements were made

during the start-up period (0–2.8 sec). Paper is concerned with the application of various calculating techniques to analyze these data to allow a calculation of the local heat-transfer coefficient for this experimental system.

Six calculating methods were employed, viz:

(1) Numerical integration method, where the time rate of change of the integrated heat content of the plug was equated to the rate of heat flow through the heat-transfer surface.
(2) Use of a Gurnie-Lurie-type plot which the authors published earlier (NASA TR R-56, 1959).
(3) An approximate solution of the one-dimensional partial differential equation for transient heat conduction.
(4) A finite difference procedure similar to that of Dusinberre.
(5) A lumped parameter technique.
(6) A graphical determination of the temperature gradient at the heat-transfer surface.

Authors discuss the relative merits of each of these methods. Conclusion is that method (1) is the best from the standpoint of estimated accuracy, ease of calculation and applicability.

The observed local heat-transfer coefficients compare reasonably well with those calculated from the Colburn equation. However, reviewer feels that this agreement may be fortuitous considering the method used in estimating the local gas temperatures.

T. W. Hoffman, Canada

426. Thorneycroft, W. T., and Thring, M. W., A theoretical method for predicting heat transfer distribution in a petroleum heater, *Trans. Inst. Chem. Engrs.* **38,** 2, 63–70, Apr. 1960.

Reviewer believes, after 35 years of experience, that precise evaluation by mathematical procedure or approach for heat transfer in tubular process heating equipment for a number of design conditions or structures is impossible. Subject paper deals with a specific heater and presumptions of greater or lesser magnitude justify calculations for heat transferred.

A presumption which enters an error of magnificent proportions is that which negates the effect of convection to the refractory surfaces. A further error of equally magnificent proportions occurs in the light treatment of the space between the tubes and the wall.

For literature reference please see Reed, Tech-53-15, Western Petroleum Refiners Association, as well as Mathis, Schweppe and Wimpuss (C. F. Braun Co.) in *Petroleum Refiner* for April 1960.

R. D. Reed, USA

427. Chung, P. M., and Anderson, A. D., Heat transfer around blunt bodies with non-equilibrium boundary layers, Proc. Heat Transf. Fluid Mech. Inst., Stanford, Calif., June 15–17, 1960; Stanford Univ., 1960, 150–163.

The heat transfer around blunt (axisymmetric) bodies with noncatalytic, nonablating walls at constant temperature, including the effects of finite rate homogeneous dissociation and recombination, is calculated. Method of analysis includes an integral method for the equations of momentum, total enthalpy, diffusion of oxygen atoms and diffusion of nitrogen atoms. Hypersonic approximations are made. Velocity, enthalpy and concentration profiles are assumed as polynomials satisfying suitable boundary conditions. Results are presented for a speed of 26,000 ft/sec at an altitude of 150,000 ft, and a speed of 27,000 ft/sec at an altitude of 200,000 ft. Results show that the chemical reactions in the boundary layer freeze rapidly around the nose and recover toward equilibrium very slowly along the afterbody. The heat-transfer distribution around the body is thus found to deviate considerably from both the equilibrium and frozen distributions.

M. Morduchow, USA

428. Antonescu, N., Calculation of optimal placement of the secondary heat exchange surfaces of steam boilers (in Roumanian), *Acad. Rep. Pop. Romine, Inst. Energetica, Stud. Cerc. Energetica* **9,** 1, 35–52, 1959.

Author's purpose is to find, analytically, optimal conditions for sectioning auxiliary heating surfaces of steam boilers, such as air preheaters and economizers and for their relative placement in the flues.

To this end he finds that in first approximation, the heating surface of an exchanger is linearly varying with an increase $O°$ given to its upper external temperature level, provided the heated fluid temperature and the heat transfer remain unchanged. Under similar conditions he obtains also a linear dependence between friction losses and this temperature rise.

Computing advantages and disadvantages of such auxiliary surfaces as functions of the increase O, and limiting the expansions to the second degree of same, he obtains by minimization an expression for O, giving the economic temperature to which the upper level of the whole preheater is to be raised and the level to which the economizer to be lowered.

For the method of obtaining the sections of the heating surfaces, only general indications are given and graphic method vaguely suggested.

The rest of the paper is devoted to the calculation of practical values for the functions entering the expression of O, under different design conditions for the heating surfaces.

The paper may be considered as an interesting first step to an analytical redetermination of the method of sectioning and placing in the flues the auxiliary heating surfaces of steam boilers, now still based on empiric considerations only.

L. G. Hamburger, Roumania

429. McCarthy, J. R., and Wolf, H., Forced convection heat transfer to gaseous hydrogen at high heat flux and high pressure in smooth, round, electrically heated tube, *ARS J.* **30,** 4, 423–425 (Tech. Notes), Apr. 1960.

430. Neice, S. E., Rutowski, R. W., and Chan, K. K., Stagnation-point heat-transfer measurements in hypersonic low-density flow, *J. Aero/Space Sci.* **27,** 5, 387–388 (Readers' Forum), May 1960.

431. Siegel, R., and Sparrow, E. M., Comparison of turbulent heat-transfer results for uniform wall heat flux and uniform wall temperature, *ASME Trans.* **82** C (*J. Heat Transfer*), 2, 152–153 (Tech. Brief), May 1960.

432. Scheele, G. F., Rosen, E. M., and Hanratty, T. J., Effect of natural convection on transition to turbulence in vertical pipes, *Canad. J. Chem. Engng.* **38,** 3, 67–73, June 1960.

The effect of natural convection on transition to a disturbed flow in a heat-transfer section of a vertical pipe has been investigated. The transition is related to the distortions of the velocity profile caused by natural convection. When natural convection is in the direction of forced flow the transition appears to occur through the growth of small disturbances. Transition occurs suddenly when natural convection is opposite the direction of forced flow and it appears to be associated with a separation of the flow at the wall.

From authors' summary

433. Cleaver, J. W., and Thomson, F., Ablation studies of low melting point bodies in a pre-heated supersonic air stream, Coll. Aero., Cranfield, Rep. 127, 29 pp., Feb. 1960.

Preliminary ablation tests were conducted using axially-symmetric and wedge-shaped models made of tin alloys with melting temperatures of about 500°K. These were placed in a wind tunnel where the air could be preheated, by passing it through a combustion chamber, to a maximum stagnation temperature of 550°K at a Mach number of 1.78. An insulated protective shroud was placed

over the model while the air flow was being raised to the operating temperature. Motion pictures of the ablation process from cone and hemispherical-cone models showed two distinct modes of melting. Under conditions where the surface temperature without ablation was close to the melting point, the melting occurred only at the stagnation point and a flat surface was formed normal to the gas stream. For much higher stream temperatures the ablating shape was paraboloidal in nature. R. Siegel, USA

434. Roberts, L., An analysis of ablation-shield requirements for manned reentry vehicles, NASA TR R-62, 58 pp., 1960.

Sublimation of material and accumulation of heat in an ablation shield is analyzed and the results are applied to the reentry of manned vehicles into the earth's atmosphere. The amount of sublimation and the temperature distribution within the ablation shield are presented as dimensionless ratios, in terms of reentry time and angle, distance from the surface, etc., as useful in engineering calculations of required thickness and thermal insulation. These quantities are shown to depend simply on maximum deceleration or total reentry time. Lifting and nonlifting vehicles are both treated. C. F. Bonilla, USA

435. Adams, M. C., Powers, W. E., and Georgiev, S., An experimental and theoretical study of quartz ablation at the stagnation point, *J. Aero/Space Sci.* **27,** 7, 535–543, July 1960.

The ablation characteristics of fused quartz are determined experimentally, utilizing an air arc wind tunnel. The principal quantity of interest, the energy absorbed per unit mass ablated, is measured at the stagnation point over a limited range of simulated flight conditions and the data are compared with theory.

Two types of quartz are investigated: (1) clear quartz having small radiation emissivity, and (2) opaque quartz with a radiative emissivity of 0.5. The theory and experimental data agree within 8 per cent for both clear and opaque quartz. A significant benefit due to radiation emission, in the case of opaque quartz, is demonstrated. The theory is applied to flight situations of practical interest. It is shown that opaque quartz will effectively absorb about 4,000 Btu/lb for ICBM and IRBM trajectories and will radiate the aerodynamic heating, with negligible ablation, for a satellite trajectory. From authors' summary

436. Ritter, M., Thermal design for Tiros, *Astronautics* **5,** 6, 40–41, 92–96, June 1960.

437. Manning, W. P., and Gauvin, W. H., Heat and mass transfer to decelerating finely atomized sprays, *AIChE J.* **6,** 2, 184–190, June 1960.

The rate of heat and mass transfer in the nozzle zone of water sprays produced by internal-mixing pneumatic nozzles and hollow-cone pressure nozzles was determined for both concurrent and crosscurrent drying air-flow patterns. The Nusselt numbers for the evaporating drops were correlated by means of the equation proposed by Ranz and Marshall for stationary drops in a moving air flow. Methods of measuring the physical properties of the water-air system were developed, and special attention was devoted to the determination of drop velocities and air humidity. From authors' summary

438. Citron, S. J., Steady-state melting of a semi-infinite medium with temperature-dependent properties, *J. Aero/Space Sci.* **27,** 6, 470–472 (Readers' Forum), June 1960.

439. Beusman, C. C., and Weisman, J., Comparison of transpiration and ablation cooling, *ARS J.* **30,** 6, 573–574 (Tech. Notes), June 1960.

440. Wilkins, J. E., Jr., Minimum mass thin fins for space radiators, Proc. Heat Transf. Fluid Mech. Inst., Stanford, Calif., June 15–17, 1960; Stanford Univ., 1960, 228–243.

Author presents the general solution to the thin fin problem wherein the conductivity and heat-transfer coefficient (b) are temperature-dependent. He seeks an optimum fin profile so that for a prescribed heat extraction and fin root temperature a minimum mass is required.

Specific solutions for such a fin are given for the conditions:

(1) $H(T) = 2\,b(T - Ta)$ b is constant

(2) $H(T) = 2\,\varepsilon\,\sigma T^4$ the emissivity ε is constant and $Ta = 0°R$

(3) $H(T) = 2\,\varepsilon\,\sigma(T^4 - Ta^4)$ ε and Ta are constant

(4) $H(T) = 2\,\varepsilon\,\sigma(T^4 - Ta^4) + 2\,b(T - Ta)$ ε and Ta are constant

In (3) the case of a superimposed constant rate of heat input per unit area (S) is included by replacing Ta^4 by $Ta^4 + S/2\,\varepsilon\,\sigma$.

In the above list $H(T)$ defines the mode of heat transfer from the surface of the fin to a sink temperature Ta. In all cases the thermal conductivity is assumed constant and in most cases the interrelated formulas, accompanied by graphical aids, for fin length, profile, heat transferred and effectiveness are given explicitly. The optimum fin is impractical in that a long, sharp-pointed fin results; therefore the author builds up the pointed tip to a rectangular tip of specified thickness and of such length as to maintain the prescribed heat extraction. In a second case he derives the equations for an optimum fin where the length, but nowhere the thickness, is prescribed.

Solution of these cases under the condition of radiation to a sink temperature of $0°R$ and discussion of the percentage increase in mass with these less effective fins is given. Solution for an optimum trapezoidal fin with prescribed minimum thickness and radiation to a $0°R$ sink is given and a graphical comparison made with the built-up tip case. The general solution for spines and formulas for the special case of radiation to a $0°R$ sink are presented.

Author points out that he does not treat the effect of the neighboring fins nor the radiator, and conventional thin fin assumptions are made.

The paper is quite good and concise, but the notation is messy. J. W. Hlinka, USA

441. Bliss, R. W., Jr., The derivations of several "plate-efficiency factors" useful in the design of flat-plate solar heat collectors, *J. Solar Energy Sci. Engng.* **3,** 4, 55–64, Dec. 1959.

The analysis treats the solar collector as a heat exchanger which derives its energy from a radiative environment. Attention is focused therefore upon the conduction and convection effects occurring within the collector plate and the radiation input is only a boundary condition of the problem. The results of the analysis are presented in the form of heat-exchanger efficiencies which depend upon the usual conduction and convection parameters plus the radiation factors that appear when radiative heat transfer is linearized. Examples of the application of the results to design problems are also presented.

In the various analyses, the radiative coefficient (b_r) is considered to be constant over the exchange surface. This procedure differs from the usual radiation fin analysis although the temperature dependency of b_r (Fig. 4 of the paper) is presented. This assumption is necessary to perform such integrations as indicated in Eq. 44 of the paper, in the closed form of Eq. 45. For the temperature ranges involved in solar collectors, this assumption is probably justified, but a comparison with an exact solution of the radiation fin would have been useful. Equation 14 appears to have a factor of 2 missing from the last two terms. J. T. Bevans, USA

442. Brandt, J. A., Irvine, T. F., Jr., and Eckert, E. R. G., A method of measuring total hemispherical emissivities at low tem-

peratures—Results for pure iron from 300 to 500 degrees Rankine, Proc. Heat Transf. Fluid Mech. Inst., Stanford, Calif., June 15–17, 1960; Stanford Univ., 1960, 220–227.

Authors describe an apparatus designed to simulate conditions approximating an ideal circular fin radiating in a black concentric enclosure. The enclosure is evacuated to eliminate convection terms. Dimensions are chosen cleverly so that the dimensionless irradiation parameter is small, thereby eliminating the necessity of measuring any heat flux and only the fin base and end temperatures are required to determine the emissivity of a material of known thermal conductivity. The apparatus was constructed symmetrically and the end temperature was measured at the center of a fin of $2L$; this produced the condition of no heat flow at the end of the fin, once the fin base temperatures were equal and the system in equilibrium.

The differential equation, under thin fin assumptions, for a fin losing heat by the fourth power law is written and a machine solution is presented graphically in terms of an end-to-base temperature ratio versus an emissivity parameter. Thus, if the two temperatures and conductivity of a given sample are known, the emissivity may be determined from this graph.

Authors estimate systematic errors of 3.5% and random errors of $\pm 7.0\%$, based on pure polished iron results which they present.

Paper is clear and easily read.

J. W. Hlinka, USA

443. Goulard, R., and Goulard, Madeleine, One-dimensional energy transfer in radiant media (in English), *Inter. J. Heat Mass Transfer* **1,** 1, 81–91, June 1960.

The mathematical expressions of radiant energy transfer are extended to include wall effects in simple one-dimensional geometries. Wall conditions were selected on a steady infinite flat layer so as to give a good model of a low-speed high-temperature boundary layer. This exact method gave a lower value of combined radiation and convective flux than would be estimated by conduction only when calculated from the assumed temperature profile.

W. L. Sibbitt, USA

444. Struss, R. G., Solar furnace determination of high-temperature absorption coefficients, *J. Solar Energy Sci. and Engng.* **4,** 2, 21–26, Apr, 1960.

Recent experiments have demonstrated that a solar furnace serves as an excellent tool for establishing heat absorption coefficients of materials at extremely high temperatures. An outline of the experiments with a naval brass sample (60.4% Cu, 39.6% Zn) illustrates the general method used. A sample was soaked at 1575°F and quenched in an ice bath so that the single-phase beta structure could be retained. This sample was then exposed in the furnace for 1.7 seconds and sectioned, polished, etched, and photographed. The *ASM Metals Handbook* gave the melting point at the exposed face, 1645°F, the temperature between the single-phase and two-phase regions near the exposed face, 1400°F, and the temperature between the two-phase region and the original structure, 675°F. The solar energy incident on the earth was calculated by calorimetry to be 1.9 calories/cm²/minute. The McAdams' equation is used for calculating the temperature profile of a semi-infinite solid by rapid heating for a short period. With a furnace efficiency of 30 per cent the absorption coefficient for brass is 0.17. From author's summary

445. Clarke, J. F., An elementary study of gas injection and sublimation into a simple shear layer, Coll. Aero., Cranfield, Rep. 126, 18 pp., Feb. 1960.

Author presents an analytical treatment for injection into a simple shear layer flowing over a surface (Couette flow). First the injection of a perfect gas into another perfect gas is considered and the effect on the heat transfer is found. Then the surface is assumed to sublime so that the injection rate is dependent on the surface temperature and hence is coupled with the heat-transfer problem. A brief discussion of the sublimation process is made using kinetic theory. R. Siegel, USA

446. Reitz, J. G., Zero gravity mercury condensing research, *Aero/Space Engng.* **19,** 9, 18–23, 46, Sept. 1960.

Mercury condenser apparatus test problems during zero g were explored by setting the liquid-vapor interface in view near the right end of the glass condenser, which permitted observation of the condensing and the liquid-vapor interface primarily for qualitative fluid mechanics phenomena. The conclusions from these tests are applicable to three areas of space power system technology—feasibility demonstration, ground test validation, and problem identification. From author's summary

447. Orlova, M. P., Reproducibility of the boiling temperature of oxygen, *Measurement Techniques* no. 5, 330–333, June 1960. (Translation of *Izmeritel'naya Tekhnika, USSR* no. 5, 23–24, May 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

448. Thuronyi, G., Annotated bibliography on evaporation, Part 2; 1948–1959, *Meteorol. Abstr.* **10,** 11, 1725–1765, Nov. 1959.

449. Mikhailov, Y., Highly intensive heat and mass transfer in dispersed media (in English), *Inter. J. Heat Mass Transfer* **1,** 1, 37–45, June 1960.

A solution is given for a system of differential equations for heat and mass transfer in a dispersed medium during phase changes. Solutions are given in the criterion form (similarity) for a one-dimensional problem (an infinite plate and a sphere with boundary conditions of the third order)....

From author's summary by W. L. Sibbitt, USA

450. Scott, P. B., Heat and mass transfer for flow past an arbitrary cylinder, AFOSR TN 59-1268 (Mass. Inst. Technol., Naval Supersonic Lab. TR-383), 87 pp., Sept. 1959.

Paper concerns cooling by injection of foreign gas into laminar incompressible boundary layer with pressure gradient. Approximate method of calculation is described based on integral of energy equation and known [Baron, J. R. and Scott, P. B., M.I.T. Naval Supersonic Lab. TR 419, Oct. 1959] similarity solutions for wedges. Use of generalization of Mangler's transformation allows extension to axisymmetric flow. Injection rate that maintains porous wall at constant temperature is determined for a circular cylinder and, compressibility in the boundary layer being ignored, for a hemisphere in supersonic flow ($M = 3.5$). In both cases wall temperature is 456°R, external temperature 570°R, and injected gas helium. W. W. Wood, Australia

451. Yagi, S., and Wakao, N., Heat and mass transfer from wall to fluid in packed beds, *AIChE J.* **5,** 1, 79–85, Mar. 1959.

The results of a number of laboratory experiments on this subject are reported. Four different solids were employed. The fluids were air in the heat-transfer experiments and water in the mass-transfer experiments. The tube containing the solids was heated externally. Radial heat transfer was assumed, but it is not entirely clear that end effects were eliminated.

Correlations employed conventional heat and mass transfer dimensionless groups. Reviewer believes additional information could be obtained from the work if the state of the bed had been included in the groups, and variables such as porosity and bed configuration considered. D. M. Vestal, Jr., USA

452. Blackman, A. W., Determination of diffusion coefficients from asymmetric concentration profiles, *ARS J.* **30,** 6, p. 557 (Tech. Notes), June 1960.

453. Sicard, L., Eyraud, L., and Elston, J., Effect of the structural transformation of a solid on the coefficient of thermal diffusivity (in French), *C. R. Acad. Sci., Paris* **249**, 5, 642–644, Aug. 1959.

454. Leslie, W. H. P., Hunter, J. J., and Robb, D., Precision temperature measurement outside the laboratory, *Research, Lond.* **13**, 7, 250–256, July 1960.

Existing resistance-thermometer techniques of millidegree accuracy were originated by Callendar in the 1890's and have not substantially altered since that date. To meet the problem of measuring with this accuracy in field tests, new robust thermometers and the use of transformer ratio-arm bridges are proposed. Three methods for the elimination of the effect of long leads to the thermometers are suggested; two of these have not been possible with the bridge methods at present favored in other laboratories. Limited tests show sufficient promise to merit investigation and to suggest that a reconsideration of the techniques used for resistance-thermometer bridges is due. The bridges described are suitable for strain gage and differential transformer use.

From authors' summary

455. Benoit, A., Air preheater for aerothermodynamic testing (in French), *Rech. Aéro.* no. 76, 35–39, May/June 1960.

Combustion

(See also Revs. 338, 373, 407, 425, 428)

456. Reynolds, W. C., Investigation of ignition temperatures of solid metals, NASA TN D-182, 71 pp., Oct. 1959.

A theory is presented which purports to relate the ignition of solid metals to an oxidation rate mechanism and radiative and convective heat transfer. Experimental data were obtained for the ignition of a number of pure metals and for certain selective alloys. Comparison of experimental data to theory shows reasonable agreement.

E. S. Starkman, USA

457. Shen, S. F., The generalized thermal energy in boundary layer type flows with chemical reaction (in English), *ZAMM* **38**, 11/12, 431–436, Nov./Dec. 1958.

The first half of this paper is devoted to extolling the attributes of the total stagnation enthalpy (which the author renames the "generalized thermal energy") in all constant-pressure laminar boundary-layer combustion problems, even when viscous dissipation and kinetic energy may be of importance. Although the analysis is done very carefully, the reviewer believes that the assumptions are unnecessarily restrictive (e.g. a binary mixture, constant and equal specific heats at constant pressure for each species, etc.), and the simplifications obtainable by utilizing the total stagnation enthalpy are already well known to most workers in the field (see, for example, the review by L. Lees, "Combustion and propulsion," Third AGARD Colloquium, Pergamon Press, New York, 1958, pp. 451-497).

The second half of the paper is concerned with the Marble-Adamson problem, i.e. the ignition (in the mixing region) of a cool combustible gas by a parallel stream of a hot inert gas which is traveling with the same velocity as the cooler gas at the initial point of contact between the two streams. Additional numerical solutions are obtained in the ignition region, and the flow is analyzed in the asymptotic region far downstream from the ignition zone. It is shown that far downstream a flame propagates into the unburnt gas at an angle determined by a laminar burning velocity which appears as an eigenvalue in an ordinary differential equation. This equation is identical to the familiar differential equation for the plane one-dimensional laminar flame, which has been solved by numerous techniques in the literature. Reviewer feels that this demonstration of the fact that the burning velocity eigenvalue equation can be obtained from the reacting boundary-layer equations is of considerable interest.

F. A. Williams, USA

458. Rosenthal, J., Exploratory methods for the determination of gas flow and temperature patterns in gas turbine combustors, Aero. Res. Lab., Melbourne, Austral., Notes ME 235, 52 pp., July 1959.

This note describes the development of equipment and methods for the measurement and interpretation of gas flow—and temperature—patterns in gas turbine combustors. These methods provide a qualitative and quantitative picture of mean flow distribution, particle history, and heat release, and it is suggested that a wide range of flow systems can be examined in this way. Experience gained in handling the equipment is described, as well as the limitations of the instruments used and the manner in which the choice of measuring grid is governed by the character of the flow system to be examined.

These methods have been applied to the examination of a Derwent VIII combustor; they have clearly shown the importance of burning zone whirl in establishing recirculation for flame piloting. The observed decrease of recirculation with heat release is discussed, as well as the secondary effect of fuel spray, and the localized action of atomizer cooling air.

Finally, improvements are suggested which should extend the operating range of the instruments used.

From author's summary

459. Krause, K. H., Boron compounds—high energy fuels (in German), *Z. Flugwiss.* **8**, 6, 172–176, June 1960.

This paper deals with fuels and propellants based on a combination of boron, hydrogen, and carbon. These fuels have a greater efficiency per unit of weight than the hydrocarbons which have been used previously. Boron compounds for general technical purposes are also listed.

From author's summary

460. Kerimov, I. G., Karsharly, K. A., and Sharifov, K. A., The normal rate of burning of mixtures of nitrogen peroxide with aromatic hydrocarbons in a Bunsen burner flame (in Azerbian), *Trudi In-ta Fiz. i Matem. Akad. Nauk AzerbSSR* **9**, 155–160, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4770.

A study has made of the normal velocity of combustion of the vapors of benzene and of nitrogen peroxide and also of the influence of addition of inert N_2 on the normal velocity of combustion. A thermodynamic calculation was carried out for the determination of the composition of the products of combustion and the temperature of the flame. The energy of activation of the combustion of the vapors of benzene and nitrogen peroxide was determined by means of the formula

$$U = C \exp\left(-\frac{E}{2RT_B}\right).$$

The experiments were made in apparatus consisting of a reservoir-mixer, heated up to the temperature of the boiling point of benzene, and of a Bunsen burner. Liquid benzene and a previously calculated quantity of nitrogen peroxide and added inert N_2 were poured into the mixer. Measurements were recorded of the volume of benzene (from the quantity of liquid benzene poured into the mixer) and of nitrogen peroxide and N_2 (from readings of the rheometers). The flame's cone was photographed. The flow of the combustible mixture in the experiments were laminar (Reynolds number $R < 1000$). The conclusions drawn were: (1) the maximum value for the normal velocity of combustion of a mixture of nitrogen peroxide with benzene vapor corresponded to $\alpha = 1.25$ and was equal to $U_n = 43.2$ cm/sec; (2) addition of N to the mixture of NO_2

and C_6H_6 reduces the normal velocity of combustion to the last; (3) the lower limit of combustion of the vapor of benzene with nitrogen peroxide corresponds to a content in the mixture of 9.45% (by volume) of benzene vapor when no nitrogen is added and to 12.8% of benzene vapor when a volume equal to 46.8% of nitrogen is of present; (4) based on the experimental values for the normal velocity of combustion and the calculated temperature of the flame the energy of activation was estimated as $E \approx 100$ kcal/mol. Three photographs are given of the cones of the flame, also an experimental curve $U_n = f(\%C_6H_6; \%N_2)$, a calculation curve $\lg U = f(T^{-1})$.

V. P. Veselago

Courtesy Referativnyi Zhurnal, USSR

461. Groetzinger, W. H., III, Polymerization of solid propellants, *ARS J.* **30,** 5, 498-499 (Tech. Notes), May 1960.

462. Ullrich, H., Mechanism of flow in swirl burners with adjustable swirl and in free jets of rotational symmetry (in German), *Forsch. Geb. Ing.-Wes.* **25,** 6, 165-181, 1959.

A complete study was made of nozzle flow technology for fuel gas, oil, and coal-dust used in steam generation. A new type swirl burner is described which uses conical ring jets. Estimates of the burning constants were made through research. Further theoretical and experimental determinations give the behavior of the different stream configurations issued from cylindrical or conical ring jets, with and without twists. Assuming frictionless flow at the center of the stream and end pressures, the flow contour was calculated. It was found the flow from a simple round jet as well as cylindrical or conical ring jets was well known as long as the output was without twist. Twisted streams occurred from small imperfections in the jets and were heretofore thought due to unsymmetry in the flow current. The results of these studies have been applied and tested in a steam generator.

J. H. Davidson, India

463. Ullrich, H., Flow phenomena in swirl-type burners having a controllable swirl, and with rotation-symmetrical free jets (in German), *Forsch. Geb. Ing.-Wes.* **26,** 1, 19-28, 1960.

This is the second, experimental, part of an extensive investigation of air-flow phenomena in swirl-type burners. The experimental layouts for swirl-type, and for swirlless nozzles, are illustrated and described; dimensioned drawings are shown of the nozzles (round, annular, and conical nozzles without swirl, and one conical nozzle with swirl). Dimensioned drawing of the pressure-measuring pitot-tube is also given. Graphs are shown of the streamlines from an annular nozzle without swirl, of the static pressure and velocity values at various radial and axial positions in the stream. Characteristic curves are given also for the air flow from a nozzle with swirl. The stability of possible stream configurations—full stream, annular stream, and wall stream—is discussed, and represented in graph. Author concludes that for swirl-free flow the conditions can be calculated with fair approximation to theory, but for flow with swirl the calculation does not yield good agreement because the instabilities caused by the swirl produce asymetrical flow configurations.

Inasmuch as the experiments were carried out without combustion, the results are not fully applicable to a burning flame; nevertheless some useful conclusions can be drawn also for flow under combustion conditions. It is pointed out that the experiments were made in free space, while combustion takes place in an enclosed space; therefore the experimental results can be applied to a combustion space only if the nozzle diameter is small compared with the dimensions of the combustion space, and the flow is not near to a wall surface. Keeping these differences and restrictions in mind the theories and experiments described can serve as guidance in estimating the conditions under combustion.

K. J. DeJuhasz, USA

464. Reznyakov, A. B., Combustion process of a jet using pulverized coal (in Russian), Issled. Fiz. Osnov Rabochego Protesessa Topol i Pechei, Alma-Ata, Akad. Nauk KazSSR, 1957, 361-379; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4768.

An approximate theory is worked out for the combustion of a jet of pulverized coal applicable to the conditions prevailing in reverberatory (smelting) furnaces. In the scheme investigated the pulverized coal-air jet travels in a rectilinear horizontal channel of constant section while the solid dispersion phase of the jet burns in the gaseous medium with a rapidly decreasing concentration of oxygen. The flow is considered to be single-dimensional, isobaric and steady. In order to calculate the velocity of motion of the jet, known principles for free isothermal turbulent flows are employed. Taking advantage of the available experimental data the author concludes that the combustion of an individual particle of natural coal in the conditions of the investigation is practically the same as the surface combustion of a particle of pure carbon. This circumstance, coupled with some supplementary assumptions, enables an approximate formula to be evolved for the computation of the time required for the combustion of an individual pulverized coal particle which, in accordance with the known principle of the distribution of particles by their dimensions in the whole jet, leads to the relation determining mechanical incomplete combustion of the jet as a polydispersion system. For the purposes of verification of the obtained equation for the complete combustion of a pulverized coal jet special tests were carried out in which, employing a pilot-plant-scale furnace-oven installation, complex studies were made of the combustion process: the varying composition of the gases along the length of the furnace was determined; the temperature of the jet was measured, the magnitude of the incomplete combustion was estimated. The tests were carried out with two types of coal (Lengersk lignite and Karagandinskii coal) in the range of changes of the coefficient of surplus air from 1.15 to 2.0. The comparison of the approximate analytical correlations obtained by the author with the results of the above tests and also with the experimental data of other investigators showed satisfactory convergence.

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR

465. Bukhman, S. V., and Vulis, L. A., The temperature, velocities and time required for burning of coal dust (in Russian), *Trudi In-ta Energ. Akad. Nauk KazSSR* **1,** 61-76, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4771.

A determination was made in a quasi-stationary approximation of the temperature equilibrium as well as of the velocity of the reaction and the relation to the particle radius at an assigned temperature for the surrounding medium. The radiation heat exchange between the particles and the walls of the furnace was studied. The computation was carried out numerically at different values for the kinetic constants of the reaction, for the stoichiometric coefficient and the temperature of the medium. Cases were examined of the combustion of carbon to CO_2, to CO and to the correlation (by weight) between the oxides $(CO_2):(CO) = 1$. It was assumed that combustion did not penetrate into the pores of the particles and that the coal was ash-free. In addition, a calculation was carried out for the nonstationary process of combustion of a particle in order to estimate the time required for it to heat through. The calculations made confirm the existence of a maximum, observed in the experimental work, on the curve relating the velocity of reaction to the particle's dimensions.

V. I. Yagodkin

Courtesy Referativnyi Zhurnal, USSR

466. Konstantinesku, V. N., Investigation of the combustion of a moving homogeneous mixture of gas (in Russian), *Rev. Mécan. Appl.* **2,** 2, 43-68, 1957; *Ref. Zh. Mech.* no. 5, 1959, Rev. 4765.

Author solves the equation of continuity, the equation of quality of motion and the equation of energy for a flow of a homogeneous

combustible mixture of gases, flowing into a stationary flame with a velocity w, whose composition is known from experiments or from special theoretical analyses. The homogeneous combustible mixture is assumed to be an ideal gas with no tendency to dissociate and possessing constant heat capacity. Author disregards friction, heat conductivity and diffusion. The problem is really one of schematic planning of the combustion process in air-jet motors and in other machines or in industrial burners, where the method of stabilizers for the flame is employed. For the case of an incompressible liquid a solution is carried out of the two-dimensional and of the axisymmetrical problems, which discloses the full equivalent nature of the integral equations obtained for both the problems. Author solves these equations by assigning linear or parabolic distribution to the velocities; in the flow of burnt-out gases this distribution of velocities turns out to be close to the linear for two-dimensional flow and close to the parabolic for axisymmetrical flow. The lengths of the combustion chambers are determined to ensure complete combustion of the fuel.

In addition to combustion chambers of constant section, others with variable section are investigated, principally those with large Mach numbers at the inlet which results in an earlier crisis in the flow than where complete combustion is concerned. For flows at relatively large Mach numbers M_0 the author assumed the unburnt mixture to be compressible and for the burnt he assumes the density of the gas to be constant and equal to $q_2 = q_1/\lambda$, where q_1, q_2 are the densities ahead of the flame's front and behind it, respectively, while λ is the relation of the temperature of retardation of the burnt gas to the temperature of retardation of the unburnt gas. It is then shown that for chambers of constant and variable sections there are limiting Mach numbers which, if exceeded, result in incomplete combustion, as the flame's front will go "dead" at the ends. The solutions obtained enable determinations to be made for the optimum form and dimensions of the combustion chambers.

L. S. Dmitriev

Courtesy Referativnyi Zburnal, USSR

467. Talantov, A. V., Methods of calculation for the simplest forms of direct-flow combustion chambers (in Russian), *Izv. Vyssh. Uchebn. Zavedenii. Aviats. Tekhn.* no. 2, 112-120, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4897.

A method is given for the analytical computations of the position of the front of the flame in a direct-flow combustion chamber, the minimum length of chamber required and the loss of pressure. These problems are solved with consideration for the compressibility of the gas. The paper thus becomes a logarithmic continuation of the author's work in which a similar problem was solved, but compressibility was not taken into account [*Trudi Kazansk. Aviats. In-ta,* **38,** 1958]. The analysis which was carried out for conservation and equilibrium led the author to a system with ten unknowns which was solved by the method of successive approximations. A numerical example of the calculation is given.

G. A. Varshavskii

Courtesy Referativnyi Zburnal, USSR

Prime Movers and Propulsion Devices

(See Revs. 184, 217, 294, 324, 413, 425, 459, 461, 483, 526, 552)

Magneto-fluid-dynamics

(See also Revs. 24, 400)

468. Rossow, V. J., On Rayleigh's problem in magnetohydrodynamics, *Physics of Fluids* **3,** 3, 395-398, May/June 1960.

Solutions for the velocity profiles at the wall normal to an infinite plate moving impulsively in a perfectly conducting fluid from rest to speed U_0 in a direction parallel to itself (Rayleigh's problem), in the presence of a magnetic field normal to its length, are listed for three distinct cases which differ only in the boundary conditions of the electric and magnetic fields. In case I the source of the magnetic field is fixed relative to the plate; in case II it is fixed relative to the fluid; while in case III the plate is in addition a perfect conductor (Chang and Yen problem). From the differential equation for the velocity parallel to the plate, with $\sigma\mu\nu = 1$ (Chang and Yen), and tabulated boundary conditions for each of the three cases, exact solutions can be obtained by Laplace transform methods and these have been listed, together with their approximate equivalents when $\sigma\mu = 0$ (Rossow). It is shown that agreement between the exact and approximate solutions, in spite of the assumptions, inconsistent on practical grounds, $\sigma\mu\nu = 1$ and $\sigma\mu \approx 0$, is good during the early stages of the motions. Author expects that under laboratory conditions results would differ little from those derived analytically with the approximation $\sigma\mu \approx 0$.

G. A. Tokaty and M. J. Cohen, England

469. Rosen, P., Scattering of electromagnetic waves by longitudinal plasma waves, *Physics of Fluids* **3,** 3, 416-417, May/June 1960.

From the existence of scattering and diffraction of electromagnetic waves by electron structures possessing periodic properties, author argues that Bragg reflection of electromagnetic waves by longitudinal plasma waves is also possible. The parallel used to support this argument is the existence of the phenomenon in a medium of periodically varying dielectric constant. Using Bragg's relation for first-order reflection and the frequency distribution for an electron plasma wave, author derives a simple expression for the maximum scatter angle between incident and reflected electromagnetic wave, essentially in terms of Debye's length and wavelength of the electromagnetic wave. Expression could thus be used to measure temperature or electron density of a plasma wave via the Debye length's dependence on both. Possibility of this type of electromagnetic reflection is reemphasized by author who shows that, given the equivalent dielectric constant for the plasma, the differential equations for the propagation of electromagnetic waves in it are similar to Brillouin's, who showed that Bragg reflection is then possible.

G. A. Tokaty and M. J. Cohen, England

470. Borg, S. F., A phenomenon in unsteady magnetohydrodynamic flow theory, *J. Aero/Space Sci.* **27,** 6, 472-473 (Readers' Forum), June 1960.

471. Gross, R. A., Chinitz, W., and Rivlin, T. J., Magnetohydrodynamic effects on exothermal waves, *J. Aero/Space Sci.* **27,** 4, 283-290, Apr. 1960.

Authors obtain the variations of the physical characteristics of an electrically conductive fluid through a normal shock wave on the hypothesis that the magnetic field $\vec{H}$ be normal to the velocity, and that a quantity of heat Q be given to the fluid. The equation giving the ratio between the velocity after and before the shock is quite analogous to the one already known in the case in which $H = 0$; $Q \neq 0$; from this the magnetic field appears to act on the flow in a way which tends to counteract the heat addition effects.

Authors obtain, therefore, the properties shown by fuel-air mixtures at the high temperatures produced by a normal shock wave for Mach numbers up to 20, assuming the system in equilibrium conditions; and particularly they compute the electrical conductivity of this system, adopting the equation proposed by Chapman and Cowling.

C. Ferrari, Italy

472. Cole, J. D., and Lynn, Y. M., Magnetohydrodynamic simple waves, AFOSR TN 59-1302 (Calif. Inst. Technol., Guggenheim Aero. Lab.), 51 pp., Dec. 1959.

The simple wave solutions of gas dynamics are generalized to ideal magnetohydrodynamic flow (infinite conductivity, zero dissipation). For one-dimensional, steady case, equations of motion are developed in terms of flow velocities, Alfven velocities, sound velocity. System of five first-order differential equations is reduced by series of eliminations and combinations to integration of single first-order differential equation. Complete description of all possible simple waves is obtained by studying trajectories of this equation. For the case of slow waves, numerical integration is carried out.

Physical problems studied as applications include: (1) Receding piston problem, whereby infinitely conducting gas under influence of arbitrarily oriented magnetic field is acted upon by receding piston. (2) Current sheet problem, whereby steady surface current sheet is suddenly discharged into ideal conducting gas at rest, under influence of arbitrarily oriented magnetic field. Tangential magnetic field induced at surface of current sheet results in fluid motion. F. L. Wattendorf, USA

473. Friedlander, F. G., Sound pulses in a conducting medium, *Proc. Camb. Phil. Soc.* **55,** 4, 341-367, Oct. 1959.

Author considers the problem of small disturbances of a compressible, electrically conducting fluid in the presence of a magnetic field. By neglecting the displacement current and energy dissipation due to viscosity, heat conduction and Joule heating he obtains a set of hyperbolic partial differential equations of first order sometimes referred to as the Lundquist equations. The linearized form of these equations constitutes the basic mathematical frame work for investigation of small disturbances. After a preliminary analysis of plane waves in which the existence of the usual magnetoacoustic wave velocities is established, author goes on to discuss, in an interesting and simple way, the propagation of wave fronts diverging from a point. Following this he studies the three-dimensional problem of a disturbance originating in prescribed initial values of the pressure over the entire field with perturbed velocity and magnetic field initially everywhere zero. The solution to this problem is proposed in the form of integrals like those encountered in potential theory. Certain kernels which constitute the "auxiliary field" are multiplied by the initial pressure function and integrated over the entire space to obtain the perturbed values of pressure, velocity and magnetic field. The kernel functions of the auxiliary field are constructed by an adaptation of F. John's method of spherical means. The remainder of this lengthy mathematical paper is devoted to discussion of the simpler problem where the initial disturbance is confined to a small region about the origin and to analysis of the singularities of the auxiliary field functions.

Reviewer notes that author evidently did not have access to the analysis of the small disturbance problem and the formally identical shock-wave problem given by Friedrichs in New York University Report NTO-6486 (1958) or earlier in a Los Alamos report (ca. 1954). Probably for this reason author makes an erroneous statement regarding the relative magnitudes of the fast, slow and Alfven speeds for the propagation of plane waves; however this lapse does not seem to affect any of the subsequent results. Reviewer notes also that paper by Grad in "Magnetodynamics of conducting fluids," D. Bershader, ed., Stanford University Press (1959), treats from a different point of view both the same set of equations and the propagation of plane waves, but then investigates modes propagating without radial attenuation and runs into some peculiarities involving domain of dependence difficulties. It would be interesting to have a detailed comparison of the two methods of solution in order to clarify the questions raised by Grad. F. D. Bennett, USA

474. Rikitake, T., Thermo-magneto-hydrodynamic oscillations in the earth's core, *Bull. Earthquake Res. Inst., Tokyo Univ.* **37,** 3, 405-422, Sept. 1959.

Author, in connection with many of his previous researches on this subject [title source **33,** 1955; **34,** 1956; **37,** 1959; *J. Phys. Soc. Japan* **13,** 1958] studies the magnetohydrodynamic oscillations in the earth's core in relation to the theory of the earth's magnetism and its secular variation. He writes the linearized equations of magnetic and thermal fields and fluid motions by assuming the steady state of temperature expressed by a quadratic function of the radius, and as for the steady magnetic field and fluid flow, the simplest combination of Bullard's dynamo. He deduces that the coupling between fluid motion and heat transfer determines some thermo-magneto-hydrodynamic oscillations which can explain the secular variation of earth's magnetism. By applying many drastic simplifications author deduces the period of oscillation, which proves to be of about 20 years, not very far from those of actual variations. C. Ferrari, Italy

475. Germain, P., Contribution to the theory of shock waves in magneto-fluid-dynamics (in French), ONERA Publ. 97, 33 pp., 1959.

Paper examines the structure of shock waves in a real, viscous, thermally and electrically conducting gas in the presence of a magnetic field oriented arbitrarily with respect to the direction of motion. The equation of state must only satisfy Weyl's inequalities. The equations of motion are put in a form which generalizes the Lagrangian equations of mechanics and is convenient for a study of the stability of the solutions: The author finds the existence of a stable family of fast shocks (upstream velocity greater than upper small perturbation propagation speed, downstream speed above normal Alfvén speed), of an unstable family of intermediate shocks (upstream velocity above normal Alfvén speed and downstream velocity below normal Alfvén speed), and of a family of slow shocks (upstream velocity below normal Alfvén speed, downstream velocity below lower small perturbation propagation speed) which is sometimes unstable. L. Trilling, USA

476. Edmonds, F. N., Jr., Hydromagnetic stability of a conducting fluid in a circular magnetic field, *Physics of Fluids* **1,** 1, 30-41, Jan./Feb. 1958.

The theory of viscous flow between two rotating coaxial cylinders as developed by Taylor is extended to the case when the fluid is an electrical conductor and a circular magnetic field is present. The equations governing marginal stability are derived, and boundary conditions for perfectly conducting cylinders are formulated for two cases when the difference in cylinder radii is small compared to their mean. In the first case, co-rotating cylinders, the underlying characteristic value problem is solved by a variational method to show that convective instability rather than oscillatory overstability will occur for realizable magnetic field strengths. In the second case, co-rotating and counter-rotating cylinders, the underlying characteristic value problem is solved by expansion in orthogonal functions method to determine the critical Taylor numbers for marginal stability. The magnetic field inhibits the onset of instability, but this effect is quite small as the hydromagnetic interaction involves displacement but not distortion of the magnetic lines of force.

From author's summary by Y. H. Kuo, China

477. Akhiezer, I. A., and Polovin, R. V., The motion of a conducting piston in a magnetohydrodynamic medium, *Soviet Phys.-JETP* **11,** 2, 383-386, Aug. 1960. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **38,** 529-533, Feb. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

The types of waves excited in a magnetohydrodynamic medium by a uniformly moving conducting plane (piston) are investigated.

The question of the resolution of an initial discontinuity is discussed. From authors' summary

478. Dickinson, H., and Bostick, W. H., DiMarco, J. N., and Koslov, S., Observation of apparent flute-type plasma instability, *Physics of Fluids* **3,** 3, 480–481 (Letters to the Editor), May/June 1960.

479. Kihara, T., Midzuno, Y., and Kaneko, S., Transport properties of plasmas in a strong magnetic field, *J. Phys. Soc. Japan* **15,** 6, 1101–1107, June 1960.

Thermodynamics of irreversible processes is applied in this theoretical paper to discuss electrical conductivity and diffusion in a two-component fully ionized gas with a Larmor radius small compared to the mean free path and to the Debye length.

D. Ter Haar, England

480. Scott, F. R., and Wenzel, R. F., Experimental plasma flow into a vacuum magnetic cusp field, *Phys. Rev.* (2) **119,** 4, 1187–1188, Aug. 1960.

A directed dense plasma has been observed to penetrate and be detained by a vacuum cusp magnetic field. A gross measurement of the directed velocity of the deuterium plasma was $(8.5 \pm 0.5) \times 10^6$ cm/sec. Ion density in the central region of the cusp was measured to be 8.5×10^{12} at 16 μsec after injection and had a decay constant of 13.5 μsec. Magnetic probe measurements are shown which indicate the gross reaction of the magnetic field to the injected plasma. Observation of impurity emission indicates that the plasma electrons cool rapidly and that the collision-dominated plasma is in contact with the container walls at the cusp ring.

From authors' summary

481. Schmidt, G., Virial theorem for plasmas, *Physics of Fluids* **3,** 3, 481–482 (Letters to the Editor), May/June 1960.

482. French, J. B., and Muntz, E. P., Design study of the UTIA low density plasma tunnel, Univ. Toronto, Inst. Aerophys. TN 34, 56 pp., Mar. 1960.

A design study of a low density plasma tunnel has been completed. A combination of an electric-arc-powered source of high energy plasma and a cryogenic pumping system has been chosen to provide high energy flows at low pressure. The work reported covers a preliminary investigation of the arc source operating characteristics, some limit estimates of the expansion process, an experimental investigation of a "pilot plant" cryogenic pump, and the design of the over-all tunnel and pumping system based on these results. It is concluded that a versatile facility can be built which will be able to produce the following test section characteristics: hypersonic flow, static pressures less than 10 microns at 5 lb/hr mass flow, mean free paths of the order of 1 in., stagnation temperatures up to 10,000°K, and low levels of stream fluctuation and contamination. From authors' summary

483. Regirer, S. A., On convective motion of a conducting fluid between parallel vertical plates in a magnetic field, *Soviet Phys.-JETP* **10,** 1, 149–152, Jan. 1960. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **37,** 212–216, July 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The equations for the free convective motion of a conducting gas between vertical plates maintained at constant temperature in the presence of an external magnetic field are generalized to describe the situation when a temperature variation in the vertical direction occurs. The problem of the superposition of free and forced convection is discussed with a view to further generalization of the equations. The generalizations provide an exact solution of the magnetohydrodynamic equations for constant vertical temperature gradient. The critical value of Grashof's number is determined for the special case when the temperatures of the two plates are identical. J. F. Lee, USA

484. Yankov, V. V., Dynamics of a conducting gaseous sphere in a quasi-stationary electromagnetic field, *Soviet Phys.-JETP* **10,** 1, 158–160, Jan. 1960. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **37,** 224–228, July 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Investigations is made of the small oscillations of a plasma sphere of infinite conductivity.

From author's summary by F. D. Bennett, USA

485. Maecker, H., Characteristics of cylindrical arcs (in German), *Z. Phys.* **157,** 1, 1–29, Oct. 1959.

Integration of the energy equation, balancing ohmic heating with conduction losses, is facilitated by approximating the relation between the electrical conductivity and the integral of the thermal conductivity using two straight-line segments. Expressions relating electric current and field strength (or, alternatively, electric conductivity and power input) with arc diameter and fluid properties result. Physical bases for field strength-current characteristics observed experimentally are clarified. Results of calculations using this approximate method are compared favorably with results of exact calculations, both for a monatomic gas and for a diatomic gas. Approximate calculation procedure is applied then in discussions of (a) centerline temperature as a function of power input, (b) the possibility of reaching extremely high arc temperatures, (c) field strength as a function of arc diameter, and (d) the raising of arc temperature through external cooling.

Reviewer considers this lucid treatment of a simple model to be an important step toward a quantitative description of the common, but complex, electric arc. E. L. Knuth, USA

486. Bienkowski, G. K., The equation of state of an ionized gas, WADD TR 59-486, Part 2 (Mass. Inst. Technol., Nav. Supersonic Lab. TR 398), 63 pp., Sept. 1959.

487. Kerney, K. P., A discussion of two incompressible magnetohydrodynamic flows, WADD TR 59-486, Part 3, (Mass. Inst. Technol., Nav. Supersonic Lab. TR 399), 52 pp., Oct. 1959.

This report is a presentation of approximate solutions to two problems involving the flow of an incompressible viscous fluid having low electrical conductivity through a transverse magnetic field.

The first problem is that of simple pipe flow. It is shown that the effects of the Hall current and ion slip can be incorporated into the continuum solution, to a first order, and that the effects of induced properties are of the order of the magnetic Reynolds number.

The second problem involves the Falkner-Skan flow; it is shown that the external magnetic field must be of the order of the square root of the velocity divided by the length for similar solutions to exist.

Further analysis shows that, unless the conductivity vanishes outside the boundary layer, the class of magnetic fields required for similar solutions leads to singularities in the external field.

From author's summary

488. Final report on research in a comprehensive theory of plasma states and phenomena, WADD TR 59-486, Part 4 (Mass. Inst. Technol., Nav. Supersonic Lab. TR 441), 67 pp., Mar. 1960.

This report is a summary of the research conducted under Contract AF33(616)-5693. The material is covered more completely in report WADD TR 59-486, Parts I, II, and III (Massachusetts Institute of Technology Naval Supersonic Laboratory Technical Reports 373, 398, and 399, respectively). [See two preceding reviews and AMR **13**(1960), Rev. 2575.]

The thermodynamic state equation of a plasma; the influence of

the magnetic field on the transport properties, as well as the thermodynamic state; and elementary fluid flow problems are summarized in this report. From summary

489. Elmore, W. C., Tuck, J. L., and Watson, K. M., On the inertial-electrostatic confinement of a plasma, *Physics of Fluids* **2,** 3, 239–246, May–June 1959.

Paper reports on a theoretical discussion of an inertial-electrostatic scheme for the confinement of a plasma. In this system, the inside of an evacuated sphere is formed into a hot cathode electron emitter, and a spherical grid maintained at +Vg with respect to the cathode accelerates the electrons inward. Near the center, they will be stopped by mutual repulsion and be reflected back toward the outer surface. If the surface of the cathode sphere is formed of material with a favorable secondary electron coefficient and if the positive grid is driven at an appropriate frequency, large electron currents can be obtained. It is hoped that high ion densities may be obtained in a confined region near the center of a sphere under conditions suitable for economic production of thermonuclear power.

The discussion is inconclusive but suggests that the ions cannot be confined to yield regions of sufficiently high ion density.

Y.-H. Pao, USA

490. Zhigulev, V. N., The phenomenon of ejection by an electrical discharge, *Soviet Phys.-Doklady* **5,** 1, 36–39, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130,** 2, 280–283, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

The theory of an electrical discharge in a medium of finite conductivity is examined. It is shown that an axially symmetric discharge is, in principle, accompanied by motion of the medium—the ejection effect. The laws of similarity for an axially symmetric discharge are derived, and self-similar solutions of its equation are given. From author's summary

491. Harned, B. W., Magnetic effect in a T-tube, *ARS J.* **30,** 7, p. 656, p. 705 (Tech. Notes), July 1960.

492. Kusukawa, K., On the high-speed flow of a compressible conductive fluid past a slender body, *J. Aero/Space Sci.* **27,** 6, 551–553 (Readers' Forum), June 1960.

The two-dimensional high-speed flow of a compressible conductive fluid past a thin airfoil was investigated recently by Sears and Resler (in the case of high conductivity σ) and Sakurai (in the case of low conductivity σ). Author studies the flow past an insulated three-dimensional slender body of thickness ratio t.

From author's summary

493. Kemp, N. H., Hydromagnetic effects on heating and shear at a three-dimensional stagnation point in hypersonic flow, *J. Aero/Space Sci.* **27,** 6, 553–554 (Readers' Forum), June 1960.

494. Barthel, J. R., and Lykoudis, P. S., The slow motion of a magnetized sphere in a conducting medium, *J. Fluid Mech.* **8,** 2, 307–314, June 1960.

The flow over a uniformly magnetized sphere is analyzed using the Stokes flow model. Solution is an iterative one starting with the velocity field from the classical Stokes solution and the magnetic field determined by magnetostatic equations. Two iterations are carried out, and agreement within 10% between the two is found at a Hartmann number of about twenty.

H. Yoshihara, USA

495. Golosman, B. S., Determination of pitch and yaw rates of models in free-flight ranges by magnetic induction, *J. Aero/Space Sci.* **27,** 8, 638–639 (Readers' Forum), Aug. 1960.

496. Kogan, M. N., Plane flow of a perfectly conducting fluid with the magnetic field nearly parallel to the velocity, *Soviet Phys.-Doklady* **5,** 1, 40–42, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130,** 2, 284–286, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

497. Skuridin, G. A., and Stanyukovich, K. P., Approximate solution of the problem of motion of a conducting plasma, *Soviet Phys.-Doklady* **5,** 1, 132–136, July/Aug. 1960. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **130,** 6, 1248–1251, Jan./Feb. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

498. Ellis, R. A., Jr., Goldberg, L. P., Gorman, J. G., Loss of charged particles in a stellarator during ohmic heating, *Physics of Fluids* **3,** 3, 468–473, May/June 1960.

The average charged particle confinement times τ_e in hydrogen and deuterium plasmas during ohmic heating in the B-3 stellarator have been determined. The observed values of τ_e are approximately proportional to the square root of the magnetic confining field and were less than the values expected on the basis of classical collisional diffusion. The low values of τ_e persisted when the system was, in theory, made hydromagnetically stable by the addition of helical stabilizing winding. It is inferred that the observed low confinement times are not due to a known hydromagnetic instability. From authors' summary

499. Guman, W. J., Partition of energy in a pulsed plasma accelerator, *Physics of Fluids* **3,** 3, 483–484 (Letters to the Editor), May/June 1960.

It is frequently stated that in the plasma behind a magnetically driven strong shock generated in a pulsed-type accelerator, the internal energy will equal the kinetic energy. The purpose of this note is to point out that this statement is true for a very specific case only; to show that the kinetic energy will exceed the thermal energy if the shock overtakes a uniformly moving fluid; to show that in nonsteady flow in a constant area duct further conversion of thermal to kinetic energy is achieved if the strong shock is permitted to collide head-on with a complete rarefraction wave.

From author's summary

500. Ludford, G. S. S., The effect of an aligned magnetic field on Oseen flow of a conducting fluid (in English), *Arch. Rational Mech. Anal.* **4,** 5, 405–411, Mar. 1960.

Slow flow of a viscous conducting fluid past a sphere is considered. The classical Oseen solution is modified by a magnetic field which, at infinity, is uniform and in the direction of the free stream. If the pressure of the ambient magnetic field is smaller than the dynamical pressure in the free stream, there is no effect on the Oseen value of the drag. If it is greater, however, the drag increases with the strength of the applied magnetic field and the conductivity of the fluid. (From author's summary).

Within first order of two expansion parameters, the solution is obtained in closed form. The qualitative behavior is similar to that for the case of a flat plate. Paper should be of interest to those who are concerned with flow and drag around an obstacle in magnetic field. W.-H. Chu, USA

501. Kovrizhnykh, L. M., Stability of a hollow gas conductor in a magnetic field, *Soviet Phys.-JETP* **10,** 1, 65–66, Jan. 1960. (Translation of *Zh. Eksp. Teor. Fiz., USSR* **37,** 92–94, July 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Stability conditions are obtained for a hollow gaseous conductor located in a longitudinal magnetic field.

From author's summary by F. D. Bennett, USA

Aeroelasticity

(See also Revs. 32, 509, 515)

502. Miura, K., On torsional rigidity and torsional vibration of aerodynamically heated wings having a small amount of pretwist, Aero. Res. Inst., Tokyo University Rep. 354, 77–91, May 1960.

It is shown that the effect of pretwist on the torsional rigidity of a heated wing varies with the magnitude of the destablilizing torque due to thermal stresses. Explicit expressions for "Effective rigidity" are derived to account for the effects of pretwist and thermal stresses. The vibration characteristic is defined by a differential equation of the type $x_{tt} + c_1x + c_2x^2 + c_3x^3 = 0$, whose solution can be expressed by the Weierstrass elliptical function. The vibration is therefore unsymmetrical. An approximate expression for the natural frequency is also obtained.

C. C. Wan, USA

503. Fung, Y. C. B., A summary of the theories and experiments on panel flutter, AFOSR TN 60-224, (Calif. Inst. Technol., Guggenheim Aero. Lab.), 78 pp., May 1960.

In recent years a sizable literature has grown out of the field of panel flutter. Much effort was spent in resolving several theoretical difficulties which arise one way or another when one tries to simplify the analytical problem by introducing various limiting cases and approximations. These difficulties are now fairly well understood. In the meantime, a considerable amount of numerical evaluation has been done so that the technical significance of the problem can be better appreciated.

The present article gives a review of various theories, and a summary of the panel-thickness requirements for the prevention of flutter under various circumstances. At the present time, available information on supersonic panel flutter is still incomplete. It is hoped that the present article may provide a guide to the existing literature; and, in projecting the known areas in clear relief, may serve to suggest areas for future research.

From author's summary

504. Kordes, E. E., Tuovila, W. J., and Guy, L. D., Flutter research on skin panels, NASA TN D-451, 18 pp., Sept. 1960.

Representative experimental results are presented to show the current status of the panel flutter problem. Results are presented for unstiffened rectangular panels and for rectangular panels stiffened by corrugated backing. Flutter boundaries are established for all types of panels when considered on the basis of equivalent isotropic plates. The effects of Mach number, differential pressure, and aerodynamic heating on panel flutter are discussed. A flutter analysis of orthotropic panels is presented in the appendix. From authors' summary

505. Miles, J. W., On supersonic flutter of long panels, *J. Aero/Space Sci.* **27,** 6, p. 476 (Readers' Forum), June 1960.

506. Hanin, M., High-frequency oscillation of slender bodies and wings, *J. Aero/Space Sci.* **27,** 6, 544-545 (Readers' Forum), June 1960.

507. Tuovila, W. J., and Hess, R. W., Aerodynamic damping at Mach numbers of 1.3 and 1.6 of a control surface on a two-dimensional wing by the free-oscillation method, NASA TN D-116, 21 pp., Feb. 1960.

The control surface chord was one-third the wing chord and the tests were made at zero wing incidence and covered a range of frequencies. The results show the aerodynamic damping coefficient to be small and positive at $M = 1.3$, whereas linearized inviscid flow theory predicts a small negative damping coefficient; at $M = 1.6$, however, the agreement between theory and experiment is good, both indicating positive damping. The agreement for the stiffness derivatives is moderately good at both Mach numbers, the theoretical values being as usual somewhat higher than the experimental values. A. D. Young, England

508. Stevens, J. E., The effect of thrust and drag load on the aeroelastic behavior of booster systems, *J. Aero/Space Sci.* **27,** 8, 639–640 (Readers' Forum), Aug. 1960.

Aeronautics

(See also Revs. 12, 65, 344, 346, 350, 351, 354, 393, 434)

509. Thorson, K. R., and Bohne, Q. R., Application of power spectral methods in airplane and missile design, *J. Aero/Space Sci.* **27,** 2, 107–116, Feb. 1960.

This paper illustrates some applications of power-spectral methods in the determination of dynamic loadings and response for both airplanes and missiles subject to continuous turbulence. Input-transfer-function-output relationships are discussed and a procedure outlined whereby mission design load information may be obtained utilizing high-speed digital computing equipment. Where time rate of change of the atmospheric and aerodynamic characteristics is significant, a continuous analog simulation is suggested.

From authors' summary by J. M. Hedgepeth, USA

510. Hoff, N. J., Structures and materials for finite lifetime, Advances in Aeronautical Sciences, Vol. 2 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958), Pergamon Press, 1959, 928–960.

Author presents a discussion of some of the factors that are important in restricting the lifetime of airplane, missile and spacecraft structures. The first general problem is the phenomenon of creep. The author summarizes his earlier work [AMR **6**(1953), Rev. 2523] on the necking and the rupture of rods subjected to constant tensile load and includes additional results for materials subjected to various creep laws. He also presents one particular approach to the analysis of creep buckling of columns and indicates the close agreement of results by this approach and that obtained by creep-buckling tests. This approach was developed jointly by the author and B. Fraeigs de Veubeke [AMR **11**(1958, Rev. 4448, and "Creep buckling," Chap. 13, of "High temperature effects in aircraft structures," AGARDograph no. 28, 1958] and is based on the idea that a critical value of lateral column deflection exists when the nonlinear stress-strain relation in the plastic range is taken into account.

The second general problem is the problem of protecting structures against very large amounts of aerodynamic heating. The author discusses briefly the heat-sink approach and the ablation approach. In the first, the example by Stalder [AMR **11**(1958), Rev. 3573] was cited to show the merit of various materials as structural surfaces. In the ablation problem, the author includes discussions of heat removal by melting and by burning.

T. H. H. Pian, USA

511. Davenport, E. E., and Spreemann, K. P., Thrust characteristics of multiple lifting jets in ground proximity, NASA TN D-513, 18 pp., Sept. 1960.

An investigation of a series of nozzle-lifting-surface combinations which might represent a VTOL configuration which employed direct thrust from wing- or fuselage-mounted engines for take-off has been made. The results show that the thrust characteristics within ground proximity can be made favorable. Configurations tested include a simple jet, 4, 6, and 8 exit multiple jets and a double jet with fuselage. From authors' summary

512. Tosti, L. P., Aerodynamic characteristics of a 1/4-scale model of a tilt-wing VTOL aircraft at high angles of wing incidence, NASA TN D-390, 42 pp., Sept. 1960.

The model had two propellers with hinged (flapping) blades mounted on the wing which could be tilted from 4° incidence for forward flight to 86° for hovering flight. The investigation included measurements of longitudinal stability characteristics for the low-speed portions of the transition range from 60° to 84° wing incidence at zero acceleration (steady level flight) and of lateral stability and control characteristics for wing incidences from 60° to 80° for a range of conditions simulating zero acceleration, 0.25g forward acceleration, and 0.25g deceleration.

From author's summary

513. Shaw, A. I. R., Deck landing, *J. Roy. Aero. Soc.* **64,** 593, 273-276, May 1960.

514. Morris, G. J., and Stickle, J. W., Response of a light airplane to roughness of unpaved runways, NASA TN D-510, 20 pp., Sept. 1960.

The response of a light liaison-type airplane to roughness of unpaved runways has been studied by measuring center-of-gravity acceleration as the airplane was taxied at constant speeds over two grass runways and a concrete taxiway. The results are presented in the form of acceleration distributions, acceleration power spectra, transfer functions, and average peak accelerations as functions of taxiing speed. Measurements from elevation profile surveys of the runways and taxiway are presented in the form of elevation profiles and power spectra.

From authors' summary

515. The supersonic transport—a technical summary, NASA TN D-423, 94 pp., June 1960.

Discussions are included of various problem areas in supersonic transport design. Problems discussed include performance, noise, materials, structures, loads, flying qualities, landings, airway traffic control, and use and effects of variable geometry.

From summary

Astronautics

(See also Revs. 33, 195, 306, 356, 436)

516. Leitmann, G., Establishment of a circular satellite orbit by double impulse, *J. Brit. Interplanetary Soc.* **17,** 7, 194-198, Jan./Feb. 1960.

Author studies the problems of launching a payload, with minimum fuel consumption, from the ground to a prescribed circular orbit by two impulses. The specific impulses relevant to the two impulses are specified and are not necessarily equal. In the analysis, the structure weights of the two rockets have been neglected and the second impulse is assumed to be applied at the apogee of the required Kepler ellipse of ascent. The orientation of the final orbit is free so that it can be coplanar with the transfer ellipse. The total fuel consumption is related to the components of the velocity after the application of the first impulse. It has been shown that the extreme solution yields a minium fuel consumption and that the vertical component of the velocity should be zero only when the ratio of the stage specific impulses is above a critical value. A. Ferri, USA

517. Moeckel, W. E., Trajectories with constant tangential thrust in central gravitational fields, NASA TR R-53, 73 pp., 1960.

The movement equations of a point with a variable mass in a gravitational field are established. Given that the force derived from the mass variation has a constant modulus and tangential direction, nondimensional parameters are introduced and a series of 67 graphs are shown, which enable one to reckon immediately the trajectory from the earth to any planet, passing around it in a circular orbit and returning to earth.

Some of the variables shown in the graphs are: a_0 (initial acceleration in terms of gravitational acceleration at the reference radius), V_b (hyperbolic velocity), $\delta = v_{co}t/r_0$ = nondimensional time (t = time v_{co} and r_0 circular velocity and radius at reference point), α inclination of thrust vector relative to circumferential, θ angular distance.

The use of these graphs is explained with an example where an exploratory mission to Mars is calculated. This also includes the effect of the Sun. F. R. Marsicano, Argentina

518. Miele, A., A survey of the problem of optimizing flight paths of aircraft and missiles, Boeing Scient. Res. Labs., Seattle Wash., Rep. DI-82-0050, 50 pp., July 1960.

A survey of the problem of optimizing flight paths of aircraft and missiles is presented. After reviewing the problems of Bolza, Mayer, and Lagrange, the following topics are discussed: quasi-steady flight over a flat Earth; nonsteady flight over a flat Earth; and nonsteady flight over a spherical Earth.

From author's summary

519. Michael, W. H., Jr., and Tolson, R. H., Effect of eccentricity of the lunar orbit, oblateness of the earth, and solar gravitational field on lunar trajectories, NASA TN D-227, 37 pp., June 1960.

Comparisons have been made between lunar trajectories which have been calculated by using the classic restricted three-body equations of motion and lunar trajectories (with identical injection conditions) which have been calculated by using equations of motion which include terms representing the additional effects. The results of such comparisons give an indication of whether these additional considerations should be included in trajectory calculations for particular lunar missions.

From authors' summary

520. Dugan, J. F., Jr., Analysis of trajectory parameters for probe and round-trip missions to Mars, NASA TN D-281, 68 pp., June 1960.

For one-way transfers between Earth and Mars, charts are obtained that show velocity, time, and angle parameters as functions of the eccentricity and semilatus rectum of the Sun-focused vehicle conic. From these curves are obtained others useful in planning one-way and round-trip mission to Mars. The analysis is characterized by circular coplanar planetary orbits, successive two-body approximations, impulsive velocity changes, and circular parking orbits at 1.1 planet radii. For round trips, the mission time considered ranges from 130 to 1000 days, while wait time spent in the parking orbit around Mars ranges from 0 to 454 days. Departure dates, one-way travel times, and individual velocity increments are presented for round trips requiring minimum total velocity increments. A set of 22 working charts for Earth-Mars trajectories is made available. From author's summary

521. Lenzi, E., and Presenza, E., Premise for the launching of a lunar satellite, Parts 1 & 2 (in Italian), *Riv. Aero.* **36,** 1, 29-47, Jan. 1960; **36,** 2, 243-262, Feb. 1960.

Elementary study of speed and weight requirements of a lunar probe—an exercise in high-school algebra.

W. A. Mersman, USA

522. Good, R. E., A method for predicting the lifetime of a near satellite, AFCRC TN 60-287 (Mass. Inst. Technol., Naval Supersonic Lab. TR 418), 57 pp., Jan. 1960.

The behavior of satellite orbits under the perturbing effect of atmospheric drag is studied in order to determine the lifetime of a

satellite. The wide extremes in drag coefficient, velocity, and density that a satellite experiences during one revolution is studied for possible methods of removing uncertainties in the lifetime predictions. By dividing the satellite lifetime into three phases—circularization, spiral decay, and terminal—approximate methods can be developed to estimate the satellite lifetime in each phase. The method developed is based on the law of conservation of energy. It considers a differential loss in energy per revolution through the drag; and then by integrating for N number of revolutions, the total change in the ellipse shape is determined per revolution. The lifetime of the satellite is then the sum of the revolutions in each phase. From author's summary

523. Krassovsky, V. I., Results of scientific investigations made by Soviet Sputniks and cosmic rockets (in English), *Astronaut. Acta* **6**, 1, 32–47, 1960.

Paper presents broad summary of scientific results from Sputniks I, II, and III, Luniks I and II, and some high-altitude rocket firings. It was first presented at the 14th annual meeting of the American Rocket Society and has been published in the *ARS Journal* **30**, no. 1, p. 27, Jan. 1960. Material covers variation with altitude (200–800 kilometers) of material density, electron density, hard cosmic rays, radiations, magnetic fields, and other space data including micrometeorites. A few results from Lunik II are quoted indicating the magnetic field of the moon to be not more than 50–100 gauss. No references are given to the many reports which must have been used in the preparation of this paper.
H. P. Liepman, USA

524. Lawden, D. F., and Long, R. S., The theory of correctional manoeuvres in interplanetary space (in English), *Astronaut. Acta* **6**, 1, 48–60, 1960.

During the flight of a spaceship from one planet to another a deviation from the precalculated trajectory is assumed to have taken place. Authors show how to revise the flight program so that the target planet is reached while the total change of the velocity of the spaceship (due to the correction of the trajectory and to the transfer into a circular orbit about the target planet) becomes a minimum. The deviation from the precalculated trajectory is assumed to be small enough to permit a peturbation calculation. The final formulas become functions of the measured deviation and of the data of the previous trajectory which now may be supposed to be a Keplerian arc. Formulas are finally written into a form which is suitable for practical calculations.
O. B. Hellman, Finland

525. Hill, J. A. F., Satellite re-entry with lightly loaded lifting vehicles, Mass. Inst. Technol., Naval Supersonic Lab. TR 429, 68 pp., Dec. 1959.

An analysis is presented of the use of lightweight lifting surfaces for the re-entry of earth satellites into the atmosphere. The general equations of motion of a vehicle in the earth's atmosphere are written using a parameter which combines the atmospheric density with the vehicle's wing loading so that quite general results may be obtained. Approximate analytical solutions of these equations are then found for three special cases—pull-out from a given entry angle to horizontal flight, horizontal flight, and equilibrium glide. These three maneuvers may be flown in sequence to achieve deceleration from the satellite speed to nearly sonic speed in a descent through about 250,000 feet covering a range of 2000–3000 nautical miles. Peak heating and deceleration, for which expressions are obtained, occur in the pull-out. For a vehicle whose drag polar is known, it is possible to determine at what lift coefficient the pull-out should be flown to minimize the heating; in the typical cases considered, this is found to be just beyond maximum lift, on the back side of the polar. Finally a rough estimate is made of the size of lifting surface required for the re-entry of a 1400-lb satellite with a peak temperature limitation (at the stagnation point) of 1800°F. This turns out to be equal to the area which is required to limit the sea-level landing speed to 20 knots. From author's summary

526. Tsu, T. C., Interplanetary travel by solar sail, *ARS J.* **29**, 6, 422–427, June 1959.

The results of the analysis of this paper indicate that a practical solar sail might be made of a thin plastic sheet metallized on the sunny side to reflect the sun's light. For a material with specific gravity of 1.18, the sail should be about 0.1 mils thick and about 5000 sq ft in area. The propulsive force is derived from the pressure due to the sun's light falling on and being reflected by the sail surface.

On going from Earth to Venus, a space ship gains speed and loses energy, whereas on an Earth-to-Mars trip, a space ship loses speed and gains energy. It is shown that all this is done naturally by the solar sail provided the correct sail settings are used. Round trip times for solar-sail propulsion compare favorably with those for chemical-rocket and ionic propulsions. In addition, much lower (take off mass)/(useful load) ratios are obtained with solar sails. Y.-H. Pao, USA

527. Schatzman, E., Applications of astronautics in astrophysics (in French), *Astronaut. Acta* **6**, 2/3, 159–166, 1960.

Problems in astrophysics, astronomy and cosmogony are listed for whose solutions astronautics will play an important role.
From author's summary

Ballistics, Explosions

(See Revs. 321, 372, 434)

Acoustics

(See also Revs. 12, 278, 473)

528. Post, E. J., Meaning and interpretation of acoustic momentum and acoustic radiation stress, *Phys. Rev.* (2) **118**, 5, 1113–1118, June 1960.

Radiation stress and radiation momentum in acoustics are surveyed. A new approach is suggested, treating both quantities as typical field concepts needed to complement the continuum description. Use is made of Eckart's Hamiltonian principle for a continuum and of Poynting's condition of separate observability of matter and elastic wave motion. The results are in close agreement with results derived by means of the adiabatic principle (Ehrenfest-Boltzmann principle). R. Heller, USA

529. Nomura, Y., Yamamura, I., and Inawashiro, S., On the acoustic radiation from a flanged circular pipe, *J. Phys. Soc. Japan* **15**, 3, 510–517, Mar. 1960.

As authors state, the problem of acoustic radiation from an unflanged circular pipe has been solved previously by H. Levine and J. Schvinger in 1947 [AMR **3**(1950), Rev. 986]. In this paper the authors determine the acoustic radiation into an infinite half space from a semi-infinite circular pipe. The sound field consists of steady harmonic oscillations. The authors have solved this "flanged pipe" problem for the case of $ka < 3.8317$, where k is the wave number of the vibration and a is the radius of the pipe. Physically, this condition restricts the solution's validity to frequencies which are less than that corresponding to the first resonance wavelength. Within this frequency range the authors give numerical results for the acoustic impedance, the power gain function for various angles, the transmission coefficient, the reflection coefficient and the end correction. Where possible these

results are compared with the corresponding quantities derived by Levine and Schwinger.

The present solution is found in cylindrical coordinates by superposing three velocity potentials involving Jacobi's polynomials and Weber-Schafheitlin integrals. One potential represents a plane wave along the tube axis. A second potential accounts for the reflected wave within the pipe, and the third potential gives the radiated wave outside the pipe. Boundary conditions inside the pipe and outside the pipe serve to determine the solution in these two regions of space. The determination is completed by requiring the potentials for these two regions to be continuous and by requiring that the velocities along the pipe axis be continuous at the open end of the tube. The techniques for carrying out this determination are laborious. The methods used appear to depend largely upon past analyses carried out by the senior author and previous collaborators. B. R. Parkin, USA

530. Pritchard, R. L., Mutual acoustic impedance between radiators in an infinite rigid plane, *J. Acoust. Soc. Amer.* **32,** 6, 730–737, June 1960.

A series solution has been obtained for the mutual acoustic impedance between two identical circular disks vibrating in an infinite plane. Under simplifying conditions, the resistive and reactive components of the mutual impedance each can be expressed in terms of a simple trigonometric function. The problem was formulated in terms of Bouwkamp's method of integrating over real and complex angles the square of the directional characteristic (relative sound pressure at a large fixed distance) to yield the total radiation impedance. Integrals involved here are similar to a type previously evaluated by Stenzel and may be expressed in terms of a double series containing Bessel functions of integral and half-integral order. Numerical values of the mutual acoustic impedance obtained by this method for two rigid disks are in good agreement with values obtained by Klapman by direct integration of the pressure at the surfaces of the disks. The acoustic self impedance and mutual impedance may also be calculated by the same methods for a more general type of circular disk having a prescribed radially symmetric velocity distribution.

To illustrate the applicability of these results, the total acoustic loading upon an array of circular disks is calculated by taking into account the mutual acoustic impedance between the disks comprising the array, Numerical results are given for a circular array of seven identical disks having a radius small relative to a wavelength and vibrating uniformly in a common, rigid plane.

From author's summary

531. Wilson, W. D., Speed of sound in sea water as a function of temperature, pressure, and salinity, *J. Acoust. Soc. Amer.* **32,** 6, 641–644, June 1960.

Tables for the speed of sound in sea water are presented. These tables have been prepared from an empirical formula which was derived to fit measured sound-speed data obtained over the temperature range −3°C to 30°C, the pressure range 1.033 kg/cm² to 1000 kg/cm², and the salinity range 33°/00 to 37°/00. The discrepancy of −3.0 m/sec found by Del Grosso at 1 atm, as compared to the tables of Kuwahara, is substantiated. In addition, the pressure coefficient of sound speed observed in the present work differs from that predicted by Kuwahara.

From author's summary

532. Weston, D. E., A moiré fringe analog of sound propagation in shallow water, *J. Acoust. Soc. Amer.* **32,** 6, 647–654, June 1960.

A moiré fringe analog of the normal modes of sound propagation in shallow water is described, in which interesting patterns are obtained both by direct visual observation and by photographic recording. These are analogs for the profiles of sound pressure as a function of range and depth in the underwater field due to a single-frequency source. Since phase is correctly represented, the interaction patterns due to the presence of considerable numbers of interfering modes may be investigated experimentally. This is important since mathematical analysis becomes difficult when there are more than two modes. There is a discussion of the characteristics of these patterns (including the formation of "loops") and also of those obtained by A. B. Wood in his sound propagation model experiments.

From author's summary

533. Kantarges, G. T., Some measurements of noise transmissions and stress response of a 0.020-inch Duralumin panel in the presence of air flow, NASA TN D-459, 25 pp., Sept. 1960.

The noise reduction through the test panel measured in an absorbent chamber is in general agreement with values predicted by the theoretical weight law for the flow-not-attached case. Corresponding data for the flow-attached case do not follow the weight law but rather indicate less noise reduction at the high frequencies. The main stress responses of the panel without airflow occurred at its fundamental vibration mode. In the presence of airflow the main response occurs in a vibration mode having a node line perpendicular to the direction of airflow.

From author's summary

Micromeritics

(See Revs. 279, 379, 389, 397, 437)

Porous Media

(See also Revs. 23, 204, 451)

534. de Saint-Marc, G. S., Bouvard, M., and Ma, M.-Y., Pore pressure in pressure tunnels (in French), *Houille Blanche* **15,** 2, 173–193, Mar./Apr. 1960.

In the first part, authors investigate the elastic equilibrium of an internally pressured tube, the wall of which has a finite or infinite thickness. Pressure is assumed to be applied to external wall of tube or at a given distance from the axis of tube. The radial pressure is assumed to be the same as that for flow in a porous medium and it is determined by Darcy's law.

In the second part, authors investigate the equilibrium of a pressure tunnel driven through a completely porous rock. Deductions are made on the equilibrium of pressure tunnel linings, specially for the case when the pressure varies with time, showing the dependence of the pressure in the lining on the relative permeability of the materials. Remarks on the mechanical stress calculation are made. G. Sestini, Italy

535. Saffman, P. G., Dispersion due to molecular diffusion and macroscopic mixing in flow through a network of capillaries, *J. Fluid Mech.* **7,** 2, 194–208, Feb. 1960.

Author presents an analytical treatment of the dispersion of a neutral material during viscous flow through a random network of capillaries. An extension of author's previous work [*J. Fluid Mech.* **6,** p. 321, 1959], paper covers case for which both molecular diffusion and macroscopic mixing are important. By introducing a Lagrangian correlation function both longitudinal and lateral diffusivities are calculated. Comparison with experiment shows a factor of two discrepany for the case of negligible convection. Author ascribes this difference to the fact that his network of capillaries is not a granular bed. Other differences are suggested as resulting from imperfect packing in experiments and the neglect of correlation in the theory. Reviewer believes the more likely cause to be the (perhaps) necessary limitations of any such theory. Agreement obtained is encouraging, if far from complete.

R. L. Perrine, USA

536. Morgan, P. G., The stability of flow through porous screens, *J. Roy. Aero. Soc.* **64,** 594, 359–362 (Tech. Notes), June 1960.

537. Vetrov, B. M., Petrenko, I. I., and Todes, O. M., Non-stationary flow of a gas and transfer of pressure through a porous medium, *Soviet Phys.–Tech. Phys.* **4,** 8, 930–939, Feb. 1960. (Translation of *Zh. Tekh. Fiz., Akad. Nauk USSR* **29,** 8, 1021–1031, Aug. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Paper describes theoretical and experimental investigation of the propagation of a homogeneous gas pressure wave through gas-saturated sands of different coarsenesses. In the theoretical analysis only the fundamental nonlinearity of the problem due to the compressibility of the air in the intergranular pores is taken into account. In specially designed tests the quantitatively derived theoretical laws have been subjected to verification and their limits of applicability have been analyzed.

J. C. Geyer, USA

538. Saffman, P. G., Exact solutions for the growth of fingers from a flat interface between two fluids in a porous medium or Hele-Shaw cell, *Quart. J. Mech. Appl. Math.* **12,** 2, 146–150, May 1959.

In a previous paper [*Proc. Roy. Soc. Lond.* (*A*) **245** p. 312, 1958; AMR **12**(1959), Rev. 547] Saffman and Taylor considered the motion in a Hele-Shaw cell of two immiscible liquids of differing viscosities. The theoretical prediction was confirmed experimentally that the interface is unstable to small disturbances where liquid of lesser viscosity drives the fluid of greater viscosity and a critical velocity is exceeded. Some exact solutions were found for the equations of motion of this system which represented the growth of long fingers propagating through the more viscous liquid. These all contain a dimensionless parameter λ which is an asymptotic measure of the finger width. The value of λ for fingers generated from single disturbances was 0.50 ± 0.02.

The paper under review is a continuation of this work with attention directed toward finding a mechanism to distinguish a particular value of λ and make the solution physically unique. Although the attempt was not completely successful, it is shown that a λ value of 0.50 corresponds to the solution of slowest approach to the final asymptotic state.

W. R. Foster, USA

539. Taylor, G., and Saffman, P. G., A note on the motion of bubbles in a Hele-Shaw cell and porous medium, *Quart. J. Mech. Appl. Math.* **12,** 3, 265–279, Aug. 1959.

Analytic treatment of case for bubble composed of a fluid of negligible viscosity, with gravity forces ignored, leads to family of solutions. As yet the physical effect which leads to a particular solution is unknown. Work is extended to the case with gravity forces and viscous bubble fluid. Solution indicates that bubble shape is independent of bubble fluid properties. Penetration of large asymmetrical bubbles into a channel and three-dimensional bubbles are considered. Results are descriptive also of porous media. The work is of mathematical interest.

I. N. McManus, Jr., USA

540. Galin, L. A., Unsteady filtration of ground water in the case of a narrow drain, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **23,** 4, 1129–1133, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

The position of the ground water level when there exists a narrow drain in the region occupied by a semi-infinite plane of ground water is determined. The case studied is that of unsteady motion when the narrow drain is free of any water. The Dirichlet problem for the half plane with a cut is solved by means of mapping in the complex plane. An expression for the velocity potential, which is proportional to the change of the ground level, is derived. In the interval of time $t = \frac{ml}{k}$ where m is the porosity, l is the depth of the drain, and k is the filtration coefficient, the boundary of the free surface traverses half the depth of the drain. This result is inaccurate since the theory was based on the assumption that the displacement of the ground water level near the drain wall is small, but it points out trends and this facilitates the study of drainage problems.

M. I. Yarymovych, USA

541. Gheorghita, S. I., The slow plane flow of a viscous fluid in presence of a porous cylindrical envelope (in English), *Bull. Math.* (50) **2,** 3, 277–284, 1958.

Solution of the problem is obtained through use of simplifications of the Navier-Stokes equations of motions, namely: (1) in the domain ranging from infinity to the external cylinder of the porous envelope, only part of inertial terms are retained; (2) for the motion in the porous medium, Darcy's law is accepted as true; and (3) for the flow in the interior of the envelope, being incomparably slower than in the exterior, inertial terms are completely neglected (this hypothesis is checked by following results). The pressures, and consequently the radial and peripheral velocity components, are harmonic functions which may be represented by expansions, with arbitrary constants to be determined by boundary conditions. This is easily accomplished because only the constants of the first terms of the expansions are of significant magnitude.

Reviewer is not aware of Baichorov's dissertations [*Vest. Mosk. Univ.* **10**(1951), p. 23 and **8**(1952), p. 73] concerning the same problem, in which some questionable hypothesis concerning the relation between the pressure jump and the normal velocity on the external surface of the envelope are introduced. According to author's results the pressure jump is proportional to the normal velocity, through a proportionality constant which depends on the geometrical features of the envelope.

A. Ghetti, Italy

542. Faingold, S. I., Gubergrits, M. Ya., and Brodskaya, B. Kh., The hydrodynamics of the process of subterranean gasification (in Russian), *Izv. Akad. Nauk EstSSR, Ser. Tekhn. i Fiz.-Matem. Nauk* **6,** 1, 68–78, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2813.

Some concepts are expressed on the so-called (using the authors' terminology) balanced gasification regime, when the draft is delivered to the force walls under pressure while the evacuation of the products of gasification from the delivery wells is accomplished under reduced pressure. The authors adopt the simplest calculation scheme of pressure interference of the wells in the stratum, with a remote feed contour very closely corresponding to the thin-layer strata with permeable coverings investigated in the study, but in so doing they at the same time introduce a number of inaccuracies. The problem can be solved with considerably greater precision if an investigation is made of the three-dimensional inflow to the wells in a semi-infinite homogeneous stratum, for the purposes of the first approximation. It is an extremely practical step also to utilize electromodelling, which permits an evaluation to be made of the heterogeneous patches of the strata covering the gas-containing layers.

I. A. Charnyi

Courtesy Referativnyi Zhurnal, USSR

543. Barenblatt, G. I., Borisov, Yu. P., Kamenetskii, S. G., and Krylov, A. P., Determination of two parameters of a petroleum-bearing stratum in accordance with the data on the restoration of pressure in the shut-down wells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 84–91, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2814.

A method is proposed for the analytical treatment of the curves for the restoration of the frontal pressure with the object of determining the filtration characteristics of the stratum and the wells which does not require, in contrast to previous methods, differentiation of the experimental curves. The method is based on the solution of the reverse problem on the elastic regime of filtra-

tion (the equation for heat conductivity) and provides for the computation of a number of integrals containing empirical functions, which proves to be, generally speaking, a considerably more precise operation than numerical or graphical differentiation. A correlation is obtained, in the imaginary region containing a linear linkage between the logarithm of time and some integrals from the experimental functions, measurable in the process of restoration of the pressure; this is effected after the application of Laplace's conversion to the equation for the inflow of an elastic liquid to the well and after the solution of the converted equation. Putting forward this linkage in the form of a graph of a straight line by the angular coefficient and cutting, taken on the axis of the ordinate, opens up the possibility of determining some parameters of the stratum and well. The checking of the method in laboratory conditions and on some curves for the restoration of pressure in actual walls gave good results.

I. A. Charnyi

Courtesy Referativnyi Zhurnal, USSR

544. Izyumova, A. M., and Shan'gin, N. N., Motion of sand in a horizontal crack formed as the result of hydraulic rupture of the stratum (in Russian), Neft. Kh-vo no. 4, 44-50, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2818.

The procedure and results are described for experiments on pumping a liquid (oil with a viscosity of 60 ccm at 20°) over a disk-shaped horizontal slit of constant thickness made of plexiglass. In its center an opening was modelled to represent a well. It is noted that at the beginning the sand is carried along by the flow without any appreciable diminution in the concentration; at some distance from the well the velocity of the flow falls, the concentration increases, then part of the sand falls out, "sand banks" are formed. At the next pumping the liquid with the sand moves along the channels formed in the sandbanks. The greater the quantity of liquid and the smaller the sand concentration the smaller the amount of sand settling as a sediment. Curves are given for the changes in the relative capacity (section of the whole slit divided by the section of the channel) in relation to the velocity and the time alloted to the pumping. A recommendation is made on the basis of the experiments: after the hydraulic rupture of the stratum when sand has gotten in, clean liquid should be pumped in to increase the size of the channels. It should be noted that in field conditions the crevice may become reduced in width at the points where the channels are formed, because of the rock pressure, while the liquid apparently does not move along the channels in the crevice but makes its way by filtration through the accumulated sand of increased permeability.

V. N. Nikolaevskii

Courtesy Referativnyi Zhurnal, USSR

545. Pilatovskii, V. P., Study of stability of a nonhomogeneous filtration flow in a thin conical layer (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 43-49, 1958.

It is admitted that, on the surface of a conical porous layer, there exists a curve separating two regions occupied by fluids with different specific gravities and viscosities, and the displacement of this separation curve is then discussed. With given initial and boundary conditions, the displacement law is obtained from a system of functional equations established by the author in a previous paper [*Izv. Akad. Nauk, SSSR, Otd. Tekh. Nauk*, no. 10, 1958]. Further, the first-order perturbation of this displacement is considered and the corresponding system of functional equations is written. The problem of finding the conditions in which a nonhomogeneous filtration flow is stable or unstable is examined. The necessary conditions of stability are found for the nonhomogeneous symmetrical flow through a conical layer. Finally, a particular case is treated in which the first-order perturbation has a simple form.

T. D. Oroveanu, Roumania

546. Kallstenius, T., and Wallgren, A., Pore water pressure measurement in field investigations, Proc. Roy. Swedish Geotechnical Inst. no. 13, 57 pp., 1956.

The following is the engineering significance of the contents of this pamphlet.

Knowledge of pore-water pressure is essential in determining the effective normal stress in Coulomb's shear strength equation. The shear strength, in its turn, is necessary in evaluating the stability of earthworks, such as slopes, bearing capacity of soil, and also in consolidation analysis of clays. For this purpose pore-water pressure meters are used. The authors describe the development of such meters and the methods of measurement used by the Swedish Geotechnical Institute in its field investigations, which are mostly made in clays. The authors describe the accuracy of measurements with pore-water pressure meters, time lags occurring in clayey soils, and various types of meters of Swedish make. It is pointed out that errors due to great time lags may give erratic results. With a Swedish quick-response measuring system the errors due to great time lags are much less probable.

In clays, closed measuring systems are called for. By the use of oil instead of water in the pore-water measuring system gas bubbles are practically eliminated. However, closed liquid-filled systems are sensitive to temperature. A Swedish electro-pneumatic measuring system is unaffected by temperature, and is good for low-pressure measurements. Its drawback is that it is relatively expensive.

A theory of measuring time lag is also given. In the United States, A. Casagrande has dealt with the construction of meters and measurement of pore-water pressure.

A. R. Jumikis, USA

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 12, 22, 254, 256, 257, 307, 360, 361, 523, 535, 571)

Book—547. A bibliographic investigation of engineering seismology [Studiu Bibliografic Asupra Seismologiei Inginerești], (Presented at the Conference of Seismology, Bucharest, Oct. 6-9, 1959), Bucharest, Editura Centrului de Documentare pentru Constructii, Arhitectura se Sistematizare, 1959, vii + 143 pp. (Paperbound)

The work is a collection of references, introduced by a short review of the fundamental problems and contributions to engineering seismology.

The purpose of the paper is to underline the present trends of the field. The bibliography is devoted mainly to the theory, the design, and the execution of aseismic provisions for buildings.

Ed.

Book—548. Transactions of the Third All-union Hydrologic Congress [Trudy III Vsesoiuznogo Gidrologicheskogo S'iezda], Leningrad, Gidrometeoizdat, 1959, 3500 pp. (10 volumes).

The Third Hydrologic Congress of the USSR took place 7-17 Oct. 1957 in Leningrad, 29 years after the Second Congress of 1928. Of the 1295 persons participating in the congress, 35 were guests from other countries. The papers of the congress, published in 10 volumes, demonstrate the present state of the continental hydrology (previous congresses also covered oceanology) and trends of development. Extent of the covered field may be seen from the contents of the Transactions: 1: Proceedings and papers read at general sessions. 2: Runoff determination and forecast. 3: Hydrophysics (evaporation, snow and ice). 4: Lakes

and reservoirs. 5: Hydrodynamics and channel processes. 6: Water control (practical applications). 7: General hydrology (organization). 8: Hydrometry and methods of hydrologic studies. 9: Groundwater and problems of the underground runoff to rivers. 10: Hydrochemistry and sanitary protection of waters.

The total number of papers was 427; some of them are of importance for foreign hydrologists.

S. Kolupaila, USA

Book—549. Szesztay, K., River forecasting on the Hungarian Danube (in Hungarian with English summary), Proc. of the Hungarian Research Institute for Water Resources no. 6, Budapest, 1959, 104 pp. + 26 plates.

A very comprehensive study of the river stage forecasting based on precipitation data in the basin area and on propagation of the flood wave. A set of diagrams have been prepared for the entire reach of the Danube in Hungary, between Bratislava and Mohacs. A method of a continuous water stage forecasting 1 to 4 days in advance is also presented. Low-water forecast for navigation is discussed briefly. Although the aim of this study was methodological, and may be of interest for hydrologists in every country, this extensive work demonstrates how the practical forecasting service, established in Hungary in 1886, is solving this important problem. The Hungarian Danube with only few tributaries can serve as a classical example for hydrologic studies. Hungarian Research Institute for Water Resources continues, with this valuable study, its established high standards.

S. Kolupaila, USA

550. Fel'zenbaum, A. I., On the barocline layer of the sea (in Russian), *Meteorol. i Gidrologiya* no. 1, 19–24, 1956; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2590.

The basis of the solution is a system of equations for the mean turbulent motion of a viscous liquid, consisting of five equations: two equations for the horizontal motion, the equation for the hydrostatics, the equations for continuity and the conditions of incompressibility. Consequently five unknowns can be determined in this system: three components of velocity u, v, w, pressure p (level ξ) and density of the water q. Assuming that $\partial v/\partial y = 0$ (where y is the direction along the axis of the channel) and $u = 0$ and $w = 0$ with $\partial q/\partial z \neq 0$, the author obtains an equation for the velocity of the flow directed along the channel

$$A_x \frac{\partial^2 v}{\partial x^2} + A_z \frac{\partial^2 v}{\partial z^2} = 0 \qquad [1]$$

where v is the component of velocity along the axis of the canal, A_z and A_x are, respectively, the coefficients of the vertical and the horizontal exchanges of the quantity of motion. Equation [1] together with the equation for the hydrostatics and the simplified equation for the motion $2\omega q \sin \varphi v = \partial p/\partial x$ gives the possibility of finding an easy determination for the sought magnitudes: the velocity v, the density q and the height of the level of ξ with the customary boundary conditions: the parity of the friction stress on the sea's surface with the tangential stress of the wind, the adhesion on the bottom and the parity (equal to zero) of the horizontal gradients of the pressure on the bottom. In this process the vertical distribution of density on the left (in accordance with the current) bank of the channel is ascertained from observations, while the obtained expression for the distribution of density in the transverse section of the channel is ascertainable from its own structure in a very close approximation to the known model of density proposed by V. B. Shtokman [*Trudi In-ta Okeanol. Akad. Nauk SSSR* **6**, p. 26, 1951]. In conformity with the scheme obtained the flow spreads to the very bottom, but actually its velocity is unappreciably small even at a level of 300 m, independently of the accepted general depth of the canal with real numerical values for the other determining parameters. On these bases a deduction is formulated that in practice a wind current only affects the surface sea-layer, the velocities of the current rapidly diminishing with depth and their distribution in the surface barocline layer being independent of the general depth of the sea.

K. N. Fedorov

Courtesy Referativnyi Zhurnal, USSR

551. Mikhailov, V. V., Determination of pressure of a sea wave on the supports of maritime lines of electrotransmission (in Azerb.), *Azerb. Neft. Kh-vo* no. 2, 25–26, 1955; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5003.

Data are furnished on the determination of the total forces of wave pressure being exerted on models of supports of lines of electrotransmission, obtained in the wave laboratory of the Kuibyshev institute of engineering and construction in Moscow. The forces reacting and the parameters of the waves were recorded synchronously by means of a loop oscillograph. Measuring of the total forces was done with strain-gage transducers fitted on guy ropes, attached to the tops and bottoms of the model supports. This method of measurement enables the equivalent force and the point of its application to be determined. Three curves of the calculations are given, which permit the total force to be determined, and also the deflection moment and the point of application of the equivalent force in a range of wave heights up to 6 m. Author concludes that the force of the pressure and the deflection moment are directly proportional to the diameter of the pole and that in the zone of unbroken waves: (1) the deflection moment is directly proportional to the depth of the sea, (2) the total force of the pressure and its point of application do not depend on its depth. A perusal of the work leaves unexplained what bases were adopted in the choice of specific coefficients for the lateral resistance when making the recalculations.

B. Kh. Glukhovskii

Courtesy Referativnyi Zhurnal, USSR

552. Drogaitsev, D. A., Zones of compression and thinning of ice in the atmospheric pressure (in Russian), *Izv. Akad. Nauk SSSR Ser. Geofiz.* no. 11, 1332–1337, 1956; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2592.

Calculations are made for the zones described in the title. A plane divergence of the vector of velocity of the ice drift is selected as the characteristic of these zones. This operator is substituted with the divergence of the wind velocity on the sea's surface while the wind coefficient of the drift is assumed to be constant. It is also assumed that the direction of the ice drift makes an angle of 10° to the right of the isobars of atmospheric pressure. A boundary condition is introduced, expressing the immovability of the shore relatively to the ice crust. A calculation is given for the divergence in accordance with data of the atmospheric pressure at sea level in August 1956 for the sea of Lapland. It is shown that the velocity divergence of the ice drift is actually a quantitative evaluation of the phenomenon of compression and thinning of the ice in stationary conditions with whose aid calculations can be carried out on some of the navigational characteristics of the ice mass.

A. S. Sarkisyan

Courtesy Referativnyi Zhurnal, USSR

553. Laikhtman, D. L., Drift of ice fields due to the wind (in Russian), *Trudi Leningrad Gidrometeorol. In-ta* no. 7, 129–137, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2591.

An investigation is carried out of the drift due to wind action of an isolated ice-floe whose horizontal dimensions are so great that the lateral resistance of the water can be disregarded, while the coefficients of turbulent viscosity in the water and in the air do not depend on the coordinates. A system of four linear differential equations with constant coefficients and boundary conditions is derived for the steady process. The solution is found in its final

form by using elementary methods, and the velocity of drift of the ice-field and its direction are determined. This is followed by an evaluation of the relation of the coefficient of turbulent viscosity to the coordinates. The differential equations with variable coefficients are substituted with equations with constant coefficients in such a way that the tangential stresses on the surface of the ice-floe remain unchanged. With this condition in force, formulas are obtained for the determination of four constant coefficients, of interest to the author, in supplementary differential equations. It is essential to know the distribution of the velocities of wind and water in the boundary layers of the drifting ice in order to determine these coefficients from the formulas obtained. The author proposes to make these determinations from the experimental data.

He continues his paper by deriving equations for the motion of the ice-floes of a large ice-field when there is relative motion of the ice floes and lateral friction between them, and examines the simplest case which could occur, when there is a rectilinear shore and when the solution does not depend on the coordinate y (the shore coincides with the axis Oy). Here the system of equations in particular derivatives for the motion of the ice-floes degenerates to a system of ordinary equations, which is easily solved. It follows from the solution obtained that friction between the ice-floes tends to damp down with increase of distance from the shore.

A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR

Book—554. Handbook of geophysics (United States Air Force-Geophysics Research Directorate), New York, The Macmillan Company, 1960, xvii + 642 pp. $15.

Publication of a handbook of geophysics indicates that there now exists a considerable body of scientific and technological fact and that unifying principles relating the facts are recognized. To a degree this is a true indication; this handbook brings together for the first time a very great number of geophysical data of value in operational planning and in design of structures and machines (particularly air and space craft). It is a considerable convenience to geophysicists who are often hard-pressed for quantitative data. Among the chapter titles are: Model atmospheres; Atmospheric temperature, pressure, and density; Wind; Precipitation; Clouds; Atmospheric composition; Atmospheric electricity; Geomagnetism; Meteors; Terrestrial surface parameters; Electromagnetic wave propagation; Visibility; Ionosphere; Thermal radiation; Sun; Cosmic radiation; Condensation trails; Atmospheric probes; Acoustic propagation.

However, geophysics is not yet a fully mature field, and, in the reviewer's opinion, this is not a comprehensive handbook of the sort familiar in physics or engineering. One page of text and four pages of diagrams are devoted to the oceans which cover 70% of the earth's surface. Tables of winds, cloud properties and precipitation rates, surface parameters, and others give data taken from a very few observations without sufficiently stressing the fragmentary nature of the data or the probable variability to be expected under conditions different from those under which the observations were made.

R. G. Fleagle, USA

555. List, R., Tunnel for the study of hail (in German), *ZAMP* **10**, 4, 381–415, July 1959.

Description is given of the construction and the performance of a tunnel for the study of physical process of hail formation. Atmospheric parameters in the tunnel are: Temperature down to $-40\,^{\circ}C$; maximum free water content in the air 10 g/m^3; size of drops between 1 and 200μ; highest wind speed 25 m/s. Pressure cannot be varied. Air is led into a vertical section where it is made humid and homogeneous and supplied with ice-forming nuclei after passing through a temperature adjuster and a filter. After these units comes the measuring section (25 × 25 cm) where the growth of a suspended or floating object is studied. Although result of experiment on hail formation is not described in this paper, it is expected that the tunnel will lead to a large increase in our knowledge of hail formation.

K. Isono, Japan

556. Andreoletti, J., Dynamics and statistics in meteorology (in French), *J. Scient. Meteorol.* **10**, 38, 77–86, Apr./June 1958.

Paper is rather abstract theoretical study in which forms of prediction operators based on fluid dynamics and statistical mathematics in varying proportions from pure dynamics to pure statistics are examined. Purely dynamical prediction is based on equation for vertical component of absolute vorticity for viscous compressible adiabatic atmosphere moving quasi-geostrophically. Next suggested method is to treat coefficients of dependent variable (geopotential) as constants for each time step in computation, readjusting for next time step. It is shown that vorticity equation is equivalent to a prediction operator which is linear in time derivative but quadratic in dependent variable itself. Paper then treats this class of operator generally. Letting amplitudes and phases of eigenfunctions represent a point in n-dimensional phase space, the trajectory in this space may be calculated from a matrix equation in which the matrix elements may be derived from dynamics or statistical study of past data (method of analogs). A similar method using a linear prediction operator is discussed. The question of adequateness of the linear operator relative to the quadratic is raised by author but not answered; linear method naturally involves shorter computation time.

Reviewer's opinion is that paper does not really contribute anything new to the solution of the forecasting problem, but does summarize a number of possible techniques in compact and mathematically elegant form for the French reader with a sufficiently high level of mathematical sophistication.

E. W. Barrett, USA

557. Mohri, K., Jet streams and upper fronts in the general circulation and their characteristics over the Far East, Parts 1 and 2, *Geophys. Mag., Tokyo* **29**, 1, 45–126, Nov. 1958; **29**, 3, 333–412, Aug. 1959.

Part 1 begins with a review of jet stream climatology. Jets are divided into two types: polar and subtropical. These frequently coalesce into a single strong jet near Japan. Polar jets are found associated with polar fronts; subtropical jets are associated with boundary between true tropical air and "intermediate air" of mid-latitudes. Dynamical analysis in "beta-plane" is made to deduce conditions favorable for jet development. Total of nine such conditions is deduced and summarized. It is shown that conditions are best met when (a) cold domes move southward and subside (polar jet), and (b) when tropical air moves northward in upper troposphere (subtropical jet). Front associated with latter event exists only above 500-mb level. Synoptic study of several years of aerological data is presented to show that conditions are wellfulfilled in region of Japan.

Part 2 opens with a dynamical treatment of effect of orography on quasi-geostrophic zonal current. Basic equations used are vorticity equation and adiabatic equation. Equations are solved in approximate form by linearization and by replacing variable coefficients with constant mean values. Result when applied to East Asian topography agrees qualitatively with observed winter mean pattern of motion. Remainder of paper is devoted to synoptic case studies of several jet stream situations over Japan and East Asia, in which qualitative agreement with dynamical analyses is noted.

Reviewer's opinion is that paper constitutes a very thorough and competent treatment of a very complex subject, though a few mathematical shortcuts of dubious validity are to be found. Only real criticism is with regard to excessive length of paper due to prolixity and repetition; reviewer feels that material could have been presented in much less than 160 pages.

E. W. Barrett, USA

Naval Architecture and Marine Engineering

(See also Revs. 67, 261, 262, 263, 362, 372)

558. Breslin, J. P., The pressure field near a ship propeller, *J. Ship. Res.* **1,** 4, 57–66, Mar. 1958.

Results of a theoretical study of the transient-pressure field near an operating ship propeller in the absence of other bodies are presented. Primarily the present state of the research of propeller-induced vibratory forces is discussed. Then author's method approximates a single propeller blade by a vortex line which is made up of a hub vortex, a bound vortex and a helical tip vortex. Velocities due to vortex lines are calculated by the Biot-Savart law. The total linearized pressure is also thought of as the sum of pressure components arising from every single vortex and determined from the pressure equation for the time-dependent flow of an ideal fluid. The pressure produced for a single moving propeller blade of nonzero chord and finite span is also given and it is demonstrated that the pressure formula as given by the vortex-line theory is equivalent to a specialization of the formula of the pressure mentioned in the preceding sentence, by selecting proper pressure distributions. Harmonic analysis gives also the harmonic terms of the pressure.

As a second step pressure expressions arising from the theory of Garrick and Watkins for sound-pressure field of aircraft propellers (NACA Report 1198, 1954) are given and it is shown that in the limit of zero chord their theory gives the same formula for the pressure field as found from the lifting-line theory.

T. Gerey, Hungary

559. Papir, A. N., Calculations for a water-jet propeller with a typical pump and the results of tests in an experimental ship (in Russian), *Trudĭ Leningrad Politekhn. In-ta* no. 193, 94–107, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5018.

The author in a previously published work [*Trudĭ Leningr. Politekhn. In-ta*, no. 187, 1956] proposed a method of calculation for the basic parameters of a water-jet propeller and of the specially designed axial pump used with it. In the present work a detailed account is given of the proposed method of calculation when using the pumps of typical design. Results are given of the calculations for a propeller of the type described in the designing of an actual ship, the procedure adopted when testing the ship and propeller, and the results of full-scale tests of the propeller. Tests carried out on the river Oka in the autumn of 1956 fully confirmed the soundness of the procedure adopted for a water-jet propeller and helped to disclose individual shortcomings in the propeller's set-up.

L. Ya. Reznitskii

Courtesy Referativnyi Zhurnal, USSR

560. Lindgren, H., and Johnsson, C.-A., The correlation of ship power and revolutions with model test results (in English), Medd. Stat. Skeppsprov. Anst., Goteborg no. 46, 35 pp., 1960. (Prepared for the Ninth International Towing Tank Conference, Paris, 1960.)

Different methods for analyzing the results of measurements on ship trials and comparing with the corresponding model test results are given. Preliminary hypotheses with regard to the scale effects on the wake fractions and the thrust deduction factors are empirically deduced and the scale effects on the propeller open-water characteristics are treated. The analysis methods are applied to a number of ships in order to verify the scale effect hypotheses and to deduce resistance allowances.

From authors' summary

561. Nishiyama, T., Lifting-line theory of the submerged hydrofoil of finite span; Part 1, A calculating method for obtaining hydrodynamical characteristics of the submerged hydrofoil of finite span; Part 2, Hydrodynamical characteristics of the submerged hydrofoil of dihedral angle; Part 3, Optimum distribution of circulation for the submerged hydrofoil of finite span; Part 4, Wall effect on the characteristics of the submerged hydrofoil of finite span, *J. Amer. Soc. Naval Engrs.* **71,** 3, 511–519, Aug. 1959; **71,** 4, 693–701, Nov. 1959; **72,** 1, 153–158, Feb. 1960; **72,** 2, 353–361, May 1960.

Basic solutions have been given by Wu and Breslin; nevertheless, author communicates a lot of original results in a form useful for immediate application. The paper represents an extension of an article published in Volume 2 of the jubilee edition of the Japanese Society of Naval Architects. Practical people will appreciate discussions added by Dr. Silverstein. For the wholly submerged foil (part 1), the effective distribution of circulation and the variation of lift and resistance with the Froude number are discussed. Theoretical results show good agreement with rather scarce experimental evidence.

The hydrodynamic characteristics of the submerged hydrofoil with dihedral angle are thoroughly investigated. Useful is a clarification of the concepts of wave and induced resistance. Results are given for the lift and drag of the vertical hydrofoil as a special case of the dihedral. The optimum distribution of circulation deviates only moderately from the elliptic distribution. Finally, by mirroring, wall effects on lift and resistance are investigated. While the dependency upon the Froude number is impressive the ratio of hydrofoil span over width of tank is not large and almost negligible, provided this ratio is less than 0.5. Again satisfactory agreement is obtained with experimental values, and in a special case with Glauert's theory.

G. P. Weinblum, Germany

562. Spangler, P. K., Hydrodynamic design and evaluation of a size 5 reinforced-plastic minesweeping float, David W. Taylor Mod. Basin Rep. 1422, 19 pp., Apr. 1960.

An O Type, Size 5, Reinforced-Plastic Minesweeping Float was designed and fabricated at the David Taylor Model Basin. Tests were conducted in the Circulating Water Channel to determine the net buoyancy, lift, drag, and towing characteristics. Tests to verify towing characteristics were also made using a small boat in the Chesapeake Bay. After modifications to towpoint and control surfaces, the float towed in a stable manner over the speed range of 0 to 7 knots. It is concluded that a Size 5 Minesweeping Float fabricated from plastic will have satisfactory towing characteristics and will allow a substantial reduction in the handling weight.

From author's summary

563. Bailitis, E., Rudder with displaced center of pressure (in German), *Schiffstechnik* **7,** 36, 71–78, Apr. 1960.

A hollow streamlined rudder is subdivided by a central watertight plate. Port and starboard compartments are flooded by holes or slots near leading and trailing edges. Pressure differences between these points create additional circulation on each side of rudder which is in same direction as main circulation around rudder when set at an angle. The effect is an equalization of pressure distribution over the profile on pressure and suction side. This results in a displacement of center of pressure toward middle of rudder as compared with a similar conventional rudder.

Comparative tests were carried out in wind tunnel with square model rudder having holes and slots which could be closed as desired. Reynolds number from 0.29×10^6 to 0.78×10^6. With open holes and slots transverse force was diminished very little and center of pressure was displaced toward middle of rudder in whole range of angles (up to 45°), very little influenced by higher speed of wind. Author concludes that the results could be of importance for future rudder constructions.

E. R. Steneroth, Sweden

564. Gerritsma, J., The effect of a keel on the rolling characteristics of a ship, *Inter. Shipbldg. Prog.* **6,** 59, 295–304, July 1959.

Paper reports model experiments on enlarged bilge keels intended to improve the rolling characteristics of an existing ship. Of particular interest are (1) illustration of a case in which the increase in mass moment of inertia, and thus larger natural period, and decrease in metacentric height associated with the larger keels more than offset the increased damping sought, and (2) the experimental techniques and instrumentation used for rolling research at the Netherlands Ship Model Basin.

P. Eisenberg, USA

565. Golovato, P., A full-scale evaluation of passive antiroll tanks aboard an AK-type ship, David W. Taylor Mod. Basin Rep. 1414, 17 pp., Apr. 1960.

A limited number of tests was made aboard an AK-type ship to determine the effectiveness of passive antiroll tanks in reducing the roll of the ship in a seaway. Comparative runs were made with the tanks operative and inoperative at two headings relative to the sea. Roll, sway, and water transfer were measured. Spectral analysis of the records indicated that the tanks reduced the rolling by a factor of two. From author's summary

566. Arndt, B., and Roden, S., Stability in head and following seas (in German), *Schiffstechnik* **5,** 29, 192–200, Nov. 1958.

Paper is a significant contribution to the vital problem of designing ships for safety against capsizing in a seaway. Stability is computed from the transverse moment due to the pressures on the hull, taking into account the wave profile and the variation of dynamic pressure in an undisturbed wave, but neglecting the effect of the presence of the ship on this pressure distribution.

When the ship is normal to a train of waves, it is found that the stability is a minimum when it is on a wave crest. This leads to the result, well-known to seamen, that a following sea is far more dangerous than a head sea, since in the former case a ship may be on the crest of a wave for a much longer time.

Experiments on a ship model in waves gave good agreement with computed values of stability on a wave crest, although a significant variation with ship speed, which is not predicted by the theory, was found. It is concluded that it is possible to determine by calculation the minimum value of the metacentric height for safety in a head or following sea.

L. Landweber, USA

567. Swaan, W. A., Amidship bending moments for ships in waves, *Inter. Shipbldg. Prog.* **6,** 61, 398–408, Sept. 1959.

Paper presents simple method for approximate calculation of midship wave bending moment. Waves are assumed to be very low, equivalent to assuming a wall-sided hull, and to have cosine profile. Resultant gravitational and buoyant forces are assumed to be in equilibrium and dynamic forces are neglected. Typical results are shown for a range of symmetrical and asymmetrical waterplane shapes. A comparison of moments due to simple cosine waves and to trochoidal waves is made and it is shown that trochoidal wave gives higher moment at wave crest when wavelength is greater than ship length. Nonlinear effect due to fact that hull is not wall-sided throughout ship length is discussed briefly.

J. E. Goldberg, USA

568. Sharov, Yu. F., Impact of the bottom of a ship with a wind wave (in Russian), *Sudostroenie* no. 4, 5–9, 1958; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 2601.

The direct impact of a structure with a quiet horizonal surface of water is investigated; the structure consists of an infinite steel sheet joined to a rigid base by means of an elastic connection. It is assumed that the structure falls onto the water surface steel sheet first with a velocity v_0, and that then the rigid base moves with an even deceleration. An equation is derived for the motion of the sheet relative to the rigid base after the impact with the water

$$q_c\delta\left(\frac{d^2u}{dt^2}+\frac{v_0}{T}\right)+ku=p \qquad [1]$$

where δ is the thickness of the steel sheet, q_c is the density of the sheet's material, k is the coefficient of rigidity, u is the displacement of the sheet relatively to the rigid base, t is the time reckoned from the moment of contact of the sheet with the water's surface, T is the time in which the rigid base reaches zero velocity, p is the pressure. A second equation is derived from the conditions that after the above impact a plane impact wave forms in the water, spreading with a velocity of $C \approx C_0 \approx 1550$ m/sec, and the velocity of the particles of liquid $\overline{v}$ in that wave is linked with the pressure p by the relation

$$\overline{v}=\frac{P}{q_0c_0}=v-\frac{du}{dt},\quad v=v_0\left(1-\frac{t}{T}\right) \qquad [2]$$

where c_0 is the density of the water, v_0 is the velocity of sound in the quiet water, v is the velocity of the rigid base. By excluding pressure from equations [1] and [2] the author obtains a linear heterogeneous equation

$$\frac{d^2u}{dt^2}+\beta\frac{du}{dt}+\lambda^2u=\beta v_0\left[\left(1-\frac{1}{\beta T}\right)-\frac{t}{T}\right]\left(\beta=\frac{q_0C_0}{q_c\delta},\ \lambda^2=\frac{k}{q_c\delta},\ 0\leqslant t\leqslant T\right) \qquad [3]$$

By disregarding the magnitude $(\beta T)^{-1}$ in equation [3] the author obtains a solution for it and then determines the pressure p and proceeds to analyze the different cases in detail. For the case of a structure consisting of a single sheet a determination is made of the full pressure impulse on the sheet. The author makes the claim that the solution obtained by him for the determined moment of time holds good even if the dimensions of the sheets are finite. The paper concludes with an examination of the applicability of the obtained solution to the study of the impact of a ship with the water bottom first and the assertion is recorded that the theory of the author is applicable to this case and that an analysis of the damage done to the bottom of the ship, collected during sea-going tests, confirmed the correctness of the theory expounded by the author. A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR

569. Ivanov, R. N., Mechanism of transmission of energy from wind to current (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 5, 673–677, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4986.

This is a discussion on questions concerning induced wind waves. Results are given of a number of experiments carried out in the Crimean section of the marine hydrophysical institute, the object of the experiments being the study of the mechanism of wave formation on the surface of a circling liquid. The results of the experiments are used by the author for the consideration, without any sort of reservation, of the rectilinear motion of a liquid. The author records some well-known concepts on the causes of the genesis of the waves. N. N. Moiseev

Courtesy Referativnyi Zhurnal, USSR

570. Shuleikin, V. V., The breaking up of waves under the action of shoal water (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 1, 65–76, 1954; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4989.

The change in the profile of a wave in its passage through shoal water is investigated. This change is studied by means of calculations for the coefficients in a Fourier series in which a curve is disclosed reflecting the wave's profile. These coefficients change with time as the wave moves on and the author shows that the phenomenon of the break-up of the wave in shallow water is ac-

companied by an appreciable diminution of the coefficient of the first term and by a sharp rise of the remote terms of the Fourier series. The physical background of this phenomenon resulting in the described changes of the coefficients is indicated. The results obtained are used to construct successive forms of waves distorted by the shoal water, and for other issues.

L. N. Sretenskii
Courtesy Referativnyi Zhurnal, USSR

571. Rozenfel'd, A. M., A simplified procedure for calculating the velocity of wind being withstood by a ship (in Russian), *Sudostroenie* no. 2, 1–6, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 5012.

A simplification is proposed for the existing methods of calculating the boundary force of wind pressure producing the maximum angle of heel of the ship. The determination of the maximum angle is carried out graphically: the point of intersection is sought of the curve of the diagram of the heeling moments and of the curve of the diagram of the moments of static stability. Examples are given for the calculations for the boundary value of the velocity of the wind to which the ship is subjected and for the calculations for the maximum value of the angle of heeling, using the new method.

V. B. Dragomiretskii
Courtesy Referativnyi Zhurnal, USSR

Friction, Lubrication and Wear

(See also Revs. 21, 283)

572. Hunter, W. B., and Zienkiewicz, O. C., Effect of temperature variations across the lubricant films in the theory of hydrodynamic lubrication, *J. Mech. Engng. Sci., Lond.* **2**, 1, 52–58, Mar. 1960.

The effects of temperature variations within the thickness of the oil film, and the ensuing viscosity variations which are thought to be responsible for the lift in parallel surface bearings, are studied with reference to the classical case of an infinitely wide inclined pad. A numerical solution for a typical bearing is obtained for different thermal boundary conditions and a comparison with results of the classical analysis is made. Very considerable differences from the classical analysis are obtained. Some results of the heat balance in bearings are presented.

From authors' summary by R. A. Stein, USA

573. Floberg, L., Lubrication of a rotating cylinder on a plane surface, considering cavitation, Trans. Chalmers Univ. Technol. no. 216, 39 pp., 1959.

The lubrication of a rotating cylinder on a moving plane surface has already been dealt with in 1945 by Gatcombe and in 1957 by Kneschke. But both authors have used boundary conditions which are not reconcilable with the continuity of the oil flow. That concerns as well the condition that the pressure distribution ends at the point of minimum film thickness which has been employed by both as Kneschke's assumption that the pressure build-up begins at the oil film thickness equal to the thickness of the oil layer at the plane surface. Therefore, the author of the present paper has tackled the problem too in order to attain the real solution by using boundary conditions compatible with flow continuity and cavitation. This means that the pressure distribution must end with vanishing pressure gradient at a value which corresponds to the vapor pressure of the lubricant. The spot where this has to occur and with it the spot where the pressure build-up begins is fixed by the condition that the supplied oil quantity must be equal to the quantity which flows through the gap between plane and cylinder. That is, it must be $U_1 \cdot b_{is} = (U_1 + U_2) \cdot b^*/2$ (b^* = film thickness at the spot with vanishing pressure gradient, b_{is} = thickness of the oil layer at the plane surface beyond the gap, U_1, U_2 = velocity of the plane respectively at the surface of the cylinder). Owing to the vanishing pressure gradient a linear velocity distribution is formed in the cavitation region. For that reason and because of the increase of the gap's thickness the oil film is split up into strips of decreasing width interrupted by zones of oil vapor. Thus, cavitation region does not contribute to the load capacity but to the friction force.

Considering these conditions author has calculated load capacity, oil flow, power loss, and adiabatic temperature rise for various values of r/b_{min} (r = radius of the cylinder, b_{min} = minimum film thickness) and various starting points of pressure build-up.

Strictly speaking it is not correct to use Reynolds' equation even at spots where the film is not thin in proportion to the radius of the cylinder. But the results of the calculation show that the error caused by this incorrectness is not large because the practically essential pressure build-up takes place where the oil film is thin.

U. Rost, Germany

574. Savitskii, K. V., and Geraskovich, Yu. P., An investigation of the stressed state of the surface layers of rubbing bodies during sliding with change of sign (in Russian), *Fiz. Metallov i Metallovedenie* **4**, 3, 519–526, 1957; *Ref. Zh. Mekh.* no. 3, 1959, Rev. 3317.

This is an investigation of the nature of the cold-hardening of the surface layers and the thermal stability of the deformed distortions, which are observed in one-sided sign-changing friction of iron, copper, aluminum and duralumin samples. The microhardness of the samples was determined, to serve as a standard for the extent of hardening attributable to deformation. It was shown that the contact surfaces harden to a greater extent when the friction is in one direction than when the friction is variable in direction. This can be explained by the fact that part of the less stable deformation distortions are apt to level out.

L. M. Rubinshtein and Yu. I. Yagi
Courtesy Referativnyi Zhurnal, USSR

575. Jakobsson, B., and Floberg, L., The centrally loaded partial journal bearing, Trans. Chalmers Univ. Technol. no. 214, 33 pp., 1959.

The present paper has been written in order to complete the treatise on partial journal bearings. After the calculation of partial journal bearings with minimum film thickness at the trailing edge in a former paper [AMR **12**(1959), Rev. 4815], now centrally loaded partial journal bearings are discussed. The calculation of such bearings has been already executed by Raimondi and Boyd. Thus authors had to do nothing else but to transform the results of Raimondi and Boyd into the nondimensional groups which they used in their previous papers. Apart from this they improved the values of the power loss. For Raimondi and Boyd have not considered that in the cavitation region the oil does not fill the whole gap but is interrupted by stripes of oil vapor. Taking this fact into account authors obtain smaller values than Raimondi and Boyd. The deviations are higher the larger the bearing angle and the eccentricity and the smaller the width.

In the present paper the values of the load capacity, the load angle, the oil flow, the power loss, the temperature rise, and the friction coefficient are listed for bearings with 360°, 180°, 120°, and 60° bearing angles and ∞, 1, ½, and ¼ width-diameter-ratios. Finally, authors show how a centrally loaded partial journal bearing is to be designed if it is to have a minimum power loss for a given load capacity, angular velocity, and minimum oil film thickness.

U. Rost, Germany

576. Floberg, L., Experimental investigation of power loss in journal bearings, considering cavitation, Trans. Chalmers Univ. Technol. no. 215, 15 pp., 1959.

In a previous paper [AMR 11(1958), Rev. 4818] the author and B. Jakobsson have jointly performed the calculation of finite journal bearings with consideration of cavitation and found that the computed pressure distributions are in accordance with the results of measurements. Yet at that time the question remained unanswered whether the method of calculation of friction force and power loss used in the mentioned paper led to true values. Purpose of the work described in present paper is to determine this question by comparison of power loss measurements with the results of the theoretical calculation.

Object of the examination is the 360° journal bearing with an oil groove 90° before the load line and a width-diameter ratio of $v = 1$. The power loss is determined as the product of journal torque and angular velocity. In order to eliminate the power loss in the supporting ball bearings the motor and the journal shaft ball bearings are placed on a cradle and the torque of this cradle, being equal to the torque at the journal, is measured by balancing a lever with weights. Since in theory the viscosity is assumed to be constant, experimental conditions for the comparison have to be choosen which give only low temperature rises. Moreover it is provided that a large quantity of oil passes the oil groove and cools the bearing. The temperature of the oil as it leaves the bearing sides is considered as the working temperature. From the measurements, the nondimensional quantities $E_0 = E\psi/\eta U^2$ and $P_0 = P\psi^2/\eta U$ (E = power loss per unit width, P = load capacity per unit width, ψ = relative clearance, U = surface velocity, η = viscosity) are calculated and recorded, together with the theoretical values, in a diagram which represents the dependence of E_0 on P_0.

It is seen that the agreement between experiment and theory is very good at low speeds. Thus, it is proved that in the cavitation region due to the vanishing pressure gradient a linear velocity distribution exists and the oil film is split up into stripes of decreasing width with increasing gap thickness which are interrupted by zones of oil vapor. The fact that at higher speeds the experimental values of E_0 are smaller than the theoretical is only the consequence of higher temperature rises and larger variations along the oil film. In these cases the average temperature is higher than that measured for the evaluation at the bearing sides.

U. Rost, Germany

577. Vasilca, Gh., and Nica, Al., Investigations on the operating characteristics of journal-bearings made of various materials (in English), *Rev. Mécan. Appl.* **3**, 4, 481–491, 1958.

578. Sonntag, R., A frictional effect in a ball bearing arising from gyroscopic action (in German), *Ing.-Arch.* **28**, 327–334, Mar. 1959.

In the bearing considered a conical end to a shaft is supported directly on balls in a race. If there is no slipping, axes of rotation of balls are not parallel to shaft axis. At a certain speed gyroscopic torque causes balls to skid so that bearing may run hot. The effect of acceleration of shaft, as well as of steady rotation, is considered. D. C. Johnson, England

579. Drutowski, R. C., Rolling friction of balls on plates, *GM Engng. J.* **7**, 3, 25–30, July/Aug./Sept. 1960.

The rolling ball seemingly has only minor problems of friction. However, an extremely small rolling force exists which takes on importance in applications of ball bearings known as the instrument type. If the friction torque can be minimized in these bearings, the accuracy of the over-all device can be improved. Thus, to learn more about the problems of the rolling ball, the laboratory of the author's company recently studied the energy losses of balls rolling on plates, using specially constructed apparatus. Energy losses were shown as functions of load, material, and surface roughness. Confirmation was obtained of the theory that the energy lost in rolling a ball on a plate is dissipated in hysteresis losses of the elastically strained metals. An equation was derived relating the rolling force and the material damping capacity of the ball and plates. The results of this work provided information which was valuable in pursuing further studies and could be applied to bearing development. From author's summary

580. Hartman, A., and Jacobs, F. A., Effect of friction on the fatigue strength of single row riveted double cover plate joints in clad 2024-T aluminum alloy (in English), Nat. LuchtLab. Amsterdam Rap. 2064, 23 pp., Nov. 1959.

The mean fatigue strength at repeated tension for an endurance of 10^7 load cycles has been determined of double cover plate specimens in clad 2024-T aluminum alloy sheet of 1.5-mm thickness with one row of 2117-T aluminum alloy snap rivets of 4.8-mm diameter and rivet pitches of 16 and 32 mm. The fatigue strength was determined by the stair case method. A comparison of these fatigue strengths has been used to obtain an estimate of the load transfer by friction between the sheets. A second estimate of this load transfer was obtained by the decrease in fatigue strength caused by milling the ends of the rivets flush to the sheet. A study of the fretting corrosion visible on the center sheet after dismantling of the specimens showed that fretting corrosion between the sheets was limited to the cladding layer and probably had been of secondary importance. From authors' summary

581. Solov'ev, A. I., A graphoanalytical system of analysis of the friction in toothed engagements (in Russian), *Trudi Tagarogsk. Radiotekhn. In-ta* **2**, 273–283, 1958; *Ref. Zh. Mekh.* no. 5, 1959, Rev. 4737.

Methods are proposed for more precise determinations of friction in toothed engagements, enabling calculations to be made for the magnitude of the coefficients of friction, the efficiency (k.p.d.) of the engagement, with account being taken of the change of velocity of slip in relation to the geometry of the engagement and also of the sort of lubricant being used. V. A. Zinov'ev

Courtesy Referativnyi Zhurnal, USSR

Letter to the Editor

582. Re: AMR **13**(1960), Rev. 2774: **Silberstein, J. P. O., and Green, Beryl, Deformation of thick circular plates,** Aero. Res. Lab. Melbourne, Austral., SM. 265, 23 pp., Apr. 1959.

Author feels that the title of the paper might have been misleading. The problem is not rigorously covered by the "Thick plate theory" of Love as will be seen from § 312 C, p. 487 because Love's theory is not *exact*. The point is that the thickness $2b$ of the plate is of the same order as the radius of the plate and hence we are dealing with a solid of revolution and boundary conditions must be satisfied accurately not merely at $z = \pm b$ but at $r = \sqrt{x^2 + y^2} = R$ as well. The reviewer may not appreciate that the allowable distortion of high quality optical reflectors is very small indeed so that "experimental verification" is extremely tedious and difficult and at the same time the assumptions underlying the theory of elasticity are very well satisfied. The purpose of the paper was to find an exact solution of a good physical approximation. Error estimates of energy solutions are not simple and this weighs heavily against them when exact solutions are as easy to compute as is the case here. Problem 4 undoubtedly would be better solved by energy methods since it is intuitive that we are dealing with a second-order effect; however we were averse to changing method in midproblem especially when the answer required was an order of magnitude estimate and no great labor saving was involved by making a change.

J. P. O. Silberstein, Australia

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